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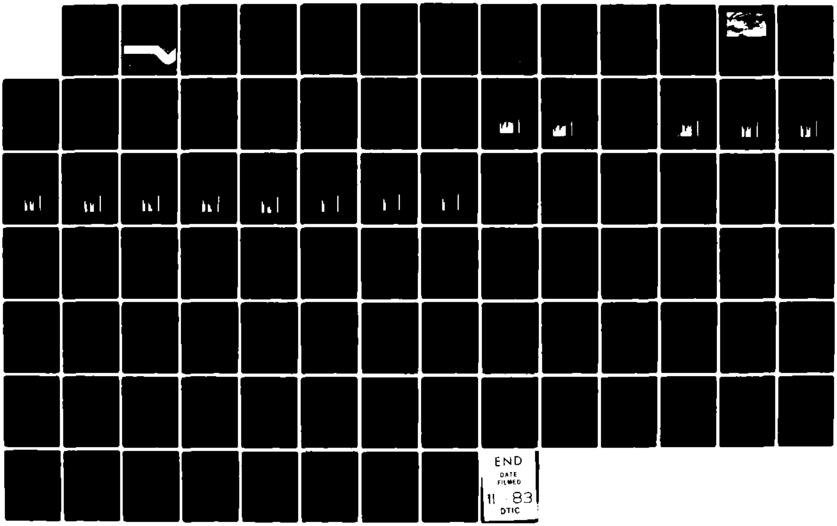

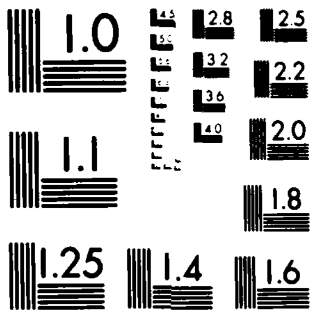

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An Evacuation Emergency Response Model Coupling Atmospheric Release Advisory Capability Output

L. C. Rosen, B. S. Lawver, D. W. Buckley,

S. P. Finn, and J. B. Swenson

AD-A133 824

January 10, 1983

Lawrence Livermore National Laboratory

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A Federal Emergency Management Agency (FEMA) sponsored project to develop a coupled set of models between those of the Lawrence Livermore National Laboratory (LLNL) Atmospheric Release Advisory Capability (ARAC) system and candidate evacuation models is discussed herein. LLNL and Science Applications, Inc. (SAI), serve as contractor and subcontractor, respectively. This report describes the ARAC system and discusses the rapid computer code developed and the coupling with ARAC output. The computer code is adapted to the use of color graphics as a means to display and convey the dynamics of an emergency evacuation. The model is applied to a specific case of an emergency evacuation of individuals surrounding the Rancho Seco Nuclear

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20. Abstract (Continued.)

Power Plant, located approximately 25 miles southeast of Sacramento, California. The graphics available to the model user for the Rancho Seco example are displayed and noted in detail. Suggestions for future, potential improvements to the emergency evacuation model are presented.

DETACHABLE SUMMARY

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L. C. Rosen, B. S. Lawver, D. W. Buckley,
S. P. Finn, and J. B. Swenson

for
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Washington, D.C. 20472
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Final report, January 10, 1983

Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550

AN EVACUATION EMERGENCY RESPONSE MODEL COUPLING ATMOSPHERIC RELEASE ADVISORY CAPABILITY OUTPUT

Detachable Summary

The Federal Emergency Management Agency (FEMA) has supported a contract in which the Lawrence Livermore National Laboratory (LLNL) has acted as contractor and Science Applications, Inc. (SAI) the subcontractor to develop a coupled set of models between those of the LLNL Atmospheric Release Advisory Capability (ARAC) system and candidate evacuation models.

A rapid computer code easily adapted for use with color graphics was developed to convey the dynamics of population evacuation in the vicinity of a nuclear power generating station. The model developed required the evacuation model to integrate calculated meteorological transport and diffusion of an atmospheric release and the resulting dose commitments as a function of time and position from the release point. An integral part of the demonstration is the display of isopleths resulting from an airborne radiactive release using ARAC data to show potential evacuation problems.

The ARAC system utilizes a suite of numerical models appropriate to a variety of atmospheric release incidents. For the purpose of this study, concentration contours coupled with the SAI evacuation model were calculated by using the MATHEW and ADPIC codes.

The evacuation emergency response model coupling ARAC output was developed for use on a VAX-780 in conjunction with a VSV11 color graphics terminal. LLNL designed the graphics package. Information is available to users of the model as a function of time to assist in either training sessions or an actual emergency response. At the beginning of an accident and for every 15 minutes of simulated time thereafter, the user may do the following:

- View a colored map indicating the road network and the number of individuals within a 10- and 15-mi radius of the accident at the NPP.
- Display dose contours for ^{131}I, ^{133}Xe, and ^{137}Cs overlayed on the colored map.
- Display a histogram showing the number of people still within the evacuation zone, those evacuated, and accumulated population doses.
- Determine directly from the color graphics displayed whether a bottleneck exists in evacuating individuals along a particular clogged road.
- Determine directly from the color graphics and overlayed contours whether a particular evacuation route(s) intersects the radiation plume endangering individuals being evacuated.
- Skip any of the preceding options or backtrack to further study a particular display.

The EVACD computer program was developed to demonstrate the feasibility of coupling an evacuation model with a color graphics system to illustrate the useful information available from such a combination. The objective of the program was achieved and has enabled improvement of the system. The following are suggestions for improvement to the developed model:

1. Add more interactive capabilities to allow operators running the model to modify road network conditions at each appropriate time step. In other words, the operator should be allowed to insert road blocks, change road preference factors, and similar types of real-time changes.
2. Add more graphics to make the model the basic tool for training emergency procedure personnel. Suggested output would aid in assessing the various evacuation decisions.
3. Generalize the dose assessment routines to cover more cases of a general nature.
4. Refine the road network model to include more specific data, such as road-dependent capacities.
5. Calibrate the model against data for past actual evacuations.
6. Develop a training program using EVACD as the main teaching tool.

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Contents

An Evacuation Emergency Response Model Coupling Atmospheric Release Advisory Capability Output

Abstract

A Federal Emergency Management Agency (FEMA) sponsored project to develop a coupled set of models between those of the Lawrence Livermore National Laboratory (LLNL) Atmospheric Release Advisory Capability (ARAC) system and candidate evacuation models is discussed herein. LLNL and Science Applications, Inc. (SAI) serve as contractor and subcontractor, respectively.

This report describes the ARAC system and discusses the rapid computer code developed and the coupling with ARAC output. The computer code is adapted to the use of color graphics as a means to display and convey the dynamics of an emergency evacuation. The model is applied to a specific case of an emergency evacuation of individuals surrounding the Rancho Seco Nuclear Power Plant, located approximately 25 miles southeast of Sacramento, California. The graphics available to the model user for the Rancho Seco test case are displayed and noted in detail. Suggestions for future, potential improvements to the emergency evacuation model are presented.

Introduction

The Federal Emergency Management Agency (FEMA) has supported a contract in which the Lawrence Livermore National Laboratory (LLNL) has acted as contractor and Science Applications, Inc. (SAI) the subcontractor to develop a coupled set of models between those of the LLNL Atmospheric Release Advisory Capability (ARAC) system and candidate evacuation models. The LLNL ARAC staff has worked in conjunction with the staff of SAI to meet the following objectives:

1. Couple the atmospheric and dose models used in the ARAC system with evacuation models developed by SAI as part of a study for the California Office of Emergency Services.
2. Study the feasibility and effectiveness of putting the output of evacuation/emergency response models such as the latest U.S. Department of Transportation package UTPS (Urban Transportation Planning System) or other network models of choice into color graphic output format compatible with ARAC's CRT outputs.
3. Integrate evacuation models into the ARAC services package, thereby extending the capability of the ARAC system.
4. Test and evaluate the concept of integrating dose and evacuation models utilizing data developed for the Rancho Seco Nuclear Power Station site in the State of California by means of a working demonstration using available equipment.

The Atmospheric Release Advisory Capability (ARAC)

Introduction

The ARAC project was initiated by the Atomic Energy Commission, now the Department of Energy (DOE), to develop a computer-based capability to produce rapid projections (advisories) of the transport, diffusion, and deposition of radioactive material released into the atmosphere. The concept's feasibility was demonstrated in 1975, after which time the central

facility was established at LLNL and computer data processing equipment was installed at selected DOE sites.[1]

The ARAC system (Fig. 1) makes available to users predictive data from proven and tested numerical models.[2-6] Geographical scales for ARAC assessments vary from regional (up to 100 km) to global (thousands of km), depending on the release conditions. At present, ARAC services are available to four DOE sites, to the Federal Aviation Administration (FAA), to DOE emergency response operations (e.g., the Nuclear Emergency Search Team), to the Nuclear Regulatory Commission's Incident Response Center, to two nuclear power plants (Indian Point and Rancho Seco), to two state offices for emergency services (New York and California), and to three Department of Defense (DOD) sites.

The ARAC center (Fig. 2) is the focal point for data acquisition, data processing, communications, and assessments through the use of interconnected minicomputers. CDC 7600 computers at the LLNL computer center are used to calculate regional and global atmospheric transport and diffusion estimates. In an atmospheric release emergency, the ARAC staff can obtain exclusive use of a CDC 7600 computer within a matter of minutes after the computer center is notified.

Meteorological data from the Air Force Global Weather Center (AFGWC) at Offutt Air Force Base, Bellevue, Nebraska, are available to the ARAC center through a high-speed data link. The ARAC center can receive, analyze, display, and store meteorological data from worldwide data sources. Selected observational and forecast data are also received on a routine scheduled basis. In an emergency, ARAC can request supplemental data, either from the AFGWC computer system or from the master data base at Carswell Air Force Base, Fort Worth, Texas. The AFGWC gives ARAC high priority under emergency conditions, thereby speeding up the response. Currently, supplemental and backup weather data are received from the National Weather Service (NWS) through normal teletype and facsimile channels. In the future, consideration will be given to including the updated NWS Automated Forecast Office Service systems in the ARAC network.

ARAC Models

The ARAC system utilizes a suite of numerical models appropriate to a variety of atmospheric release incidents. For the purpose of this study, concentration contours coupled with the SAI evacuation model were calculated by using the MATHEW and ADPIC codes. These two models are described briefly below:

MATHEW[2,3]

This flexible, three-dimensional model provides nondivergent wind fields for use in the

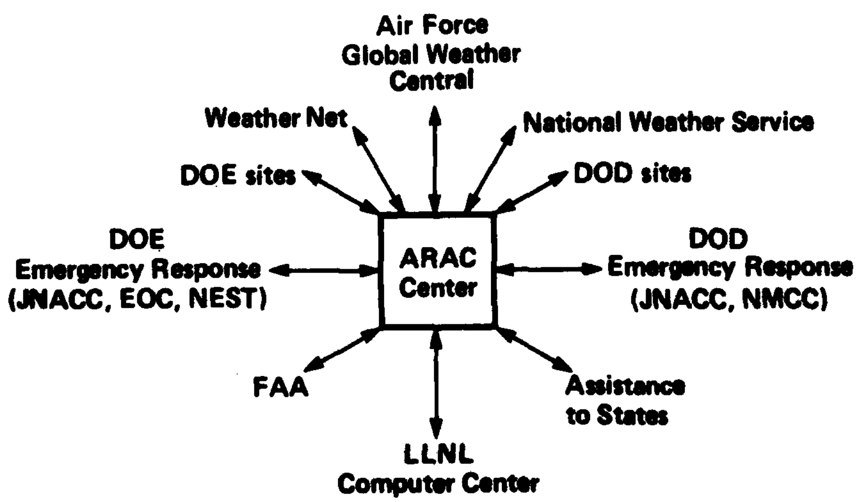


Figure 1. ARAC network.

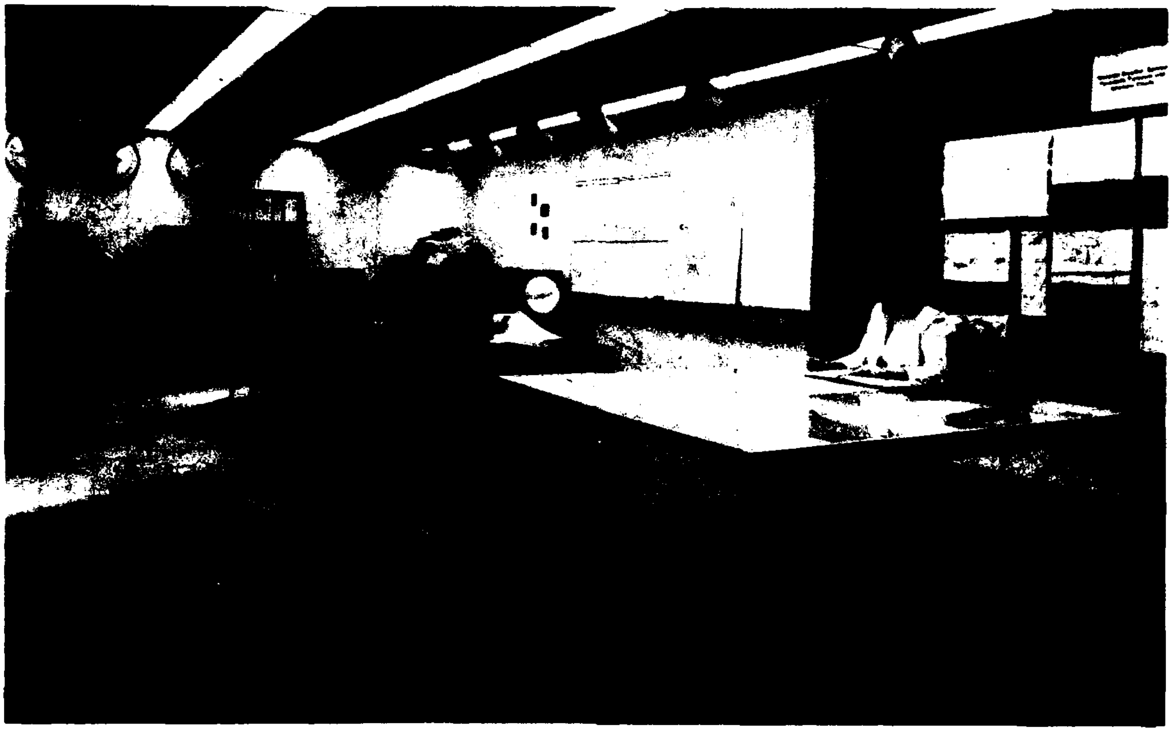


Figure 2. ARAC Central facility.

ADPIC model and in other studies. It adjusts interpolated wind-field data, subject to the constraints of mass continuity and explicitly introduced topography. Also, it is available for other studies such as assessing windpower sites and topographic influences.

ADPIC[4,5]

This three-dimensional particle-diffusion model calculates the transport and diffusion of a puff or plume in a time-varying atmospheric boundary layer. It is based on the particle-in-cell (PIC) concept, without the hydrodynamical aspects of the conventional PIC. This computer model has been used to simulate particulate and gaseous concentrations from one or more sources at distances beyond 100 km, general deposition of particles with given size distributions, and rainout. In addition, ADPIC calculations have been compared against measurements for four different field-diffusion experiments. The MATHEW/ADPIC transport and diffusion models are continually being modified and verified against field tracer studies to provide ARAC users with useful products in a timely manner.

ARAC Concentration Contours

The ARAC data for this project has been developed and calculated for radionuclide releases from the Rancho Seco Nuclear Generating Station. Rancho Seco is a 913-MWe, pressurized water reactor, nuclear generating station operated since 1975 by the Sacramento Municipal Utilities District (SMUD) at a location approximately 25 mi southeast of Sacramento, California (Fig. 3). The site is somewhat unusual in that it is not located adjacent to any river or large body of water, and waste heat is dissipated to the atmosphere through two natural-draft cooling towers. The area surrounding the plant site is almost exclusively agricultural. More densely populated areas of greater Sacramento begin about 10 mi from the site.

The plant is equipped with a number of fixed radiation monitoring systems; a gamma-sensitive

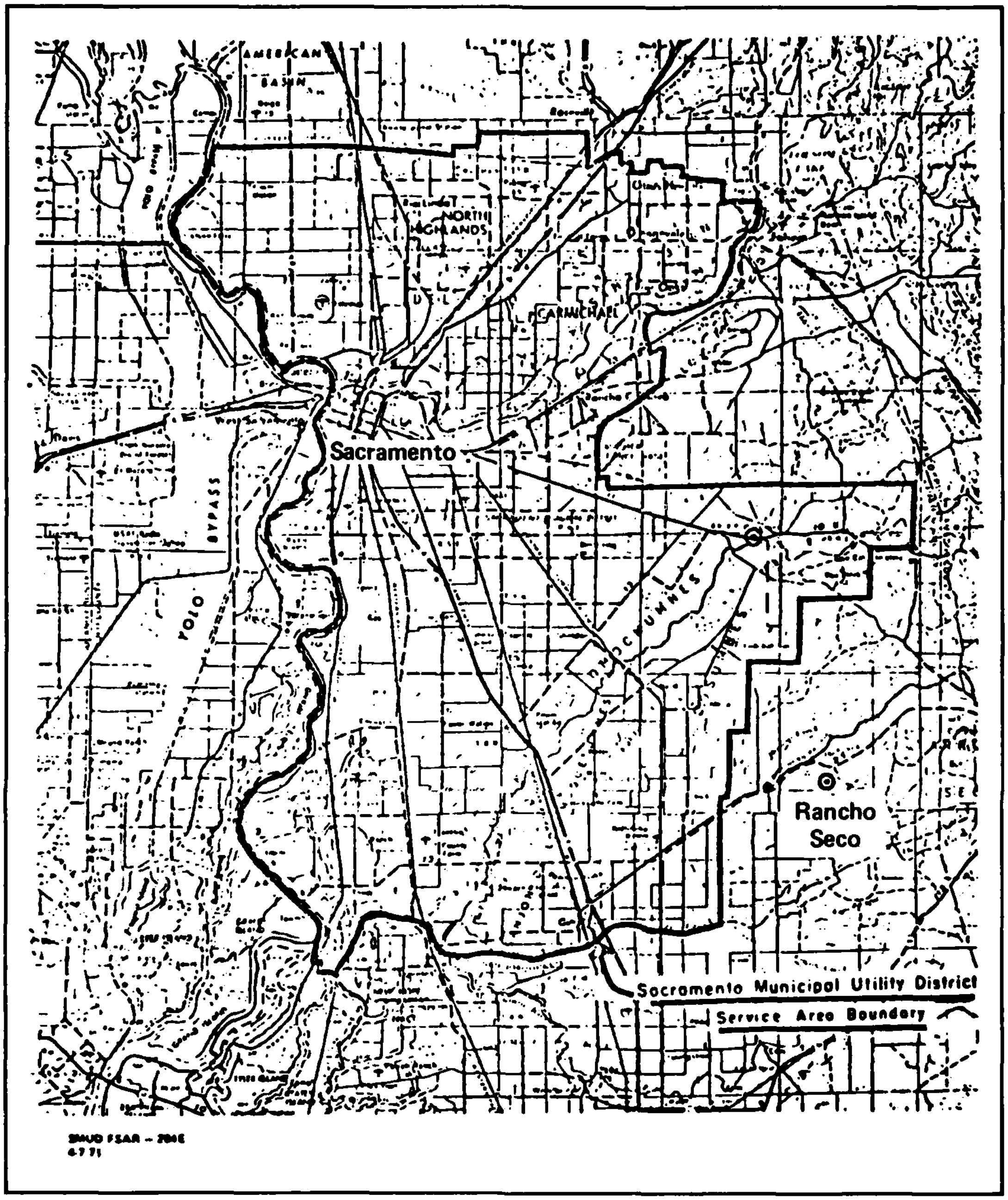


Figure 3. Map of the region surrounding the Rancho Seco Nuclear Power Plant (~25 mi southeast of Sacramento, California).

scintillation detector to measure radiation levels in the spent fuel cooling system; high-energy gamma detectors to monitor gross fuel failure; a gamma-sensitive scintillation detector to detect radiation levels in the regenerant holdup tanks discharge; and a system of gross beta scintillation counters and single-channel gamma analyzers that monitor a number of plant processes, the

ventilation systems, and the atmosphere both inside and outside the plant for gaseous and airborne particulate radioactivity.

The 200-ft meteorological tower operated by Rancho Seco is located about 3000 ft east of the reactor building. Wind speed and direction are measured at 33 and 200 ft above ground level. Temperature measurements are made at 6, 33 and 200 ft above ground level. Wind speed and direction at the 33-ft level are measured once each 10 s; the other parameters are measured once each minute.

The models employed in these ARAC calculations require the topography on the region surrounding the Rancho Seco Nuclear Power Plant (NPP) to be digitized to establish a site map. Figure 4 illustrates the topography for this region in three dimensions. The isopleths used in this report were computed by running MATHEW/ADPIC for a 60-km grid for a release time of 2.5[illegible] h. Three nuclides were released, [illegible]Cs, [illegible]Xe, and [illegible]I with release rates of 10[illegible] Ci/s, 10[illegible] Ci/s, and 1 Ci/s, respectively. These release rates were chosen by SMUD as "representative" of a potential accident. In the event of an actual nuclear accident, the release rates may be more or less. The doses given by the ARAC calculated contours would then affect the decision of state personnel to evacuate population along road networks that would intersect contours yielding dose rates deemed too high to be sustained.

Figures A-1 to A-48 in Appendix A give the full set of contours. The external, adult, whole-body dose isopleths for [illegible]Xe are shown in Figs. A-1 to A-16. The whole-body, inhalation dose contours for [illegible]Cs are in Figs. A-17 to A-32. The adult, thyroid, inhalation dose rate contours for [illegible]I are in Figs. A-33 to A-48.

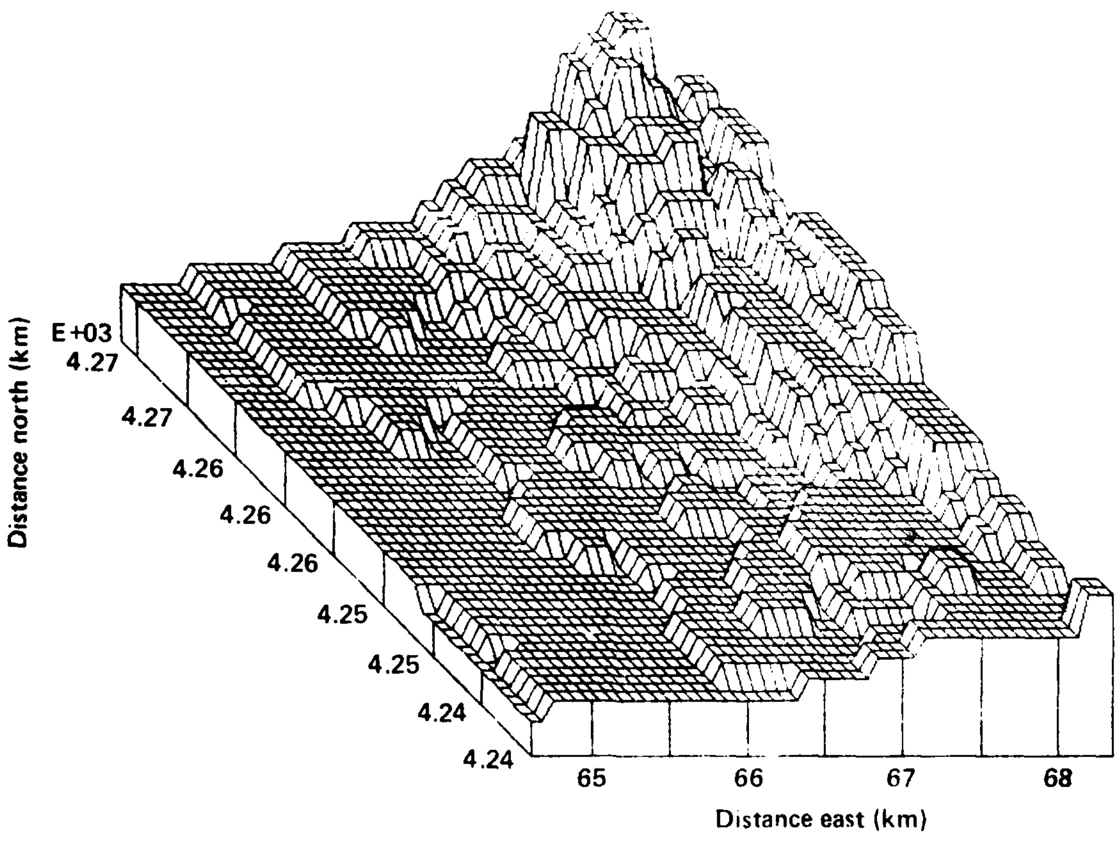


Figure 4. Three-dimensional topography of the region surrounding the Rancho Seco Nuclear Power Plant (southwest view). Grid origin UTM coordinates are x = 646.0 km, y = 4237.0 km, Z = 0 NASL. Mesh intervals are DELX = 0.750 km, DELY = 0.750 km, DELZ = 25 m.

EVACD Methodology

Methodology Overview

A rapid computer code easily adapted for use with color graphics was developed to convey the dynamics of population evacuation in the vicinity of a nuclear power generating station. The model developed also required the evacuation model to integrate the calculated meteorological transport and diffusion of an atmospheric release and the resulting dose commitments as a function of time and position from the release point. The following section discusses the methodology developed during the project.

The model was set up using a road network consisting of links and nodes overlayed on a grid system of 1600 cells (40 × 40), for which dose levels were calculated for each time step. Geometrical considerations assured the road network and cells were coupled together correctly for all calculations requiring both reference frames.

Road Network

The accommodation of vehicular traffic has been the primary consideration in the planning, design, and operation of streets and highways by appropriate groups and agencies. Much has been written and compiled about the requirements necessary to successfully design and implement road networks for use by the public. This subject is broadly referred to as "highway capacity," i.e., a measure of the effectiveness of various roadways to accommodate traffic. The determination of highway capacities requires a general knowledge of traffic behavior and a specific knowledge of traffic volumes that can be accommodated under a variety of roadway configurations and operating conditions. A rational and practical method for determining highway capacities has always been essential for an economical and sound utilization of highway transportation systems. Most work performed in the past has dealt with traffic flows in a steady-state environment. To model a dynamic evacuation situation, knowledge gained from the steady state is used to develop a time-dependent traffic flow model.

EVACD Evacuation Model

General Model Overview

EVACD models road networks as a collection of roadways and intersections that can be represented by links and nodes. Figure 5 illustrates a road network consisting of eight nodes and nine links, and uses the nomenclature of the EVACD model. All links are defined by the nodes that are at their origin and termination. The subscripts of the links identifier l are first ordered as origin node number, followed by the termination node. For example, a link extending from node 5 to node 4 is identified as l_{54}. Travel on any link is allowed in only one direction. Therefore, roadways with traffic flow in both directions require two links, as shown by l_{45} and l_{54} in Fig. 5. The arrows in Fig. 5 indicate the direction of travel on each link. Thus, most road networks can be easily represented as an integrated set of nodes and links.

A unique feature of the link network is that each is defined by a set of descriptors that gives all data parameters particular to each link. The descriptors include the following:

1. Origin node.
2. Termination node.
3. Number of travel lanes.
4. Length of link.
5. Free flow speed.
6. Standard traffic capacity.
7. Jam density.
8. All factors affecting traffic flow.

The model in EVACD does not track individual vehicles, but rather uses relationships between flows, road characteristics such as speed, density, and traffic backup, and other relevant traffic parameters. EVACD is not intended to model steady-state, random traffic problems. It was developed explicitly to solve complex evacuation problems. The model is based on the concepts found in Ref. 1.

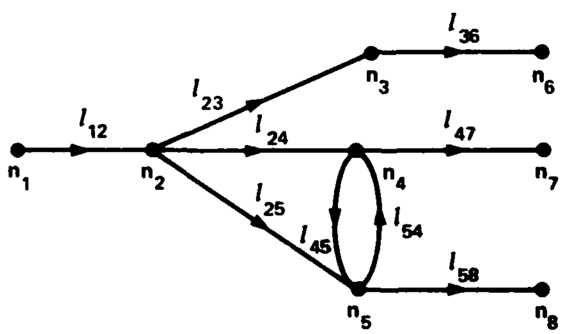


Figure 5. Representation of a road network using the nomenclature of the EVACD model.

EVACD has been designed to display the dynamics of each portion of a traffic network at snapshots in time during an evacuation. The dynamics found on each link and at each node are easily displayed, enabling identification of possible problem areas during an actual evacuation. EVACD has also been designed so that modifications and additions can easily be made in the future. (See Appendix B for a detailed discussion of the EVACD computer program and Appendix C for a listing of the EVACD main routine, subroutines, and common files.)

EVACD Model Dynamics

EVACD operates as a numerical approximation scheme to the total evacuation process. By combining the relationships of the road network parameters to a mass balance of vehicles on the network over short periods of time, an approximation of the evacuation can be calculated in a step-wise manner. This is accomplished first by determining the dynamics on each link during a short period of time or during a time step. The conditions on the link at the end of each time step are calculated, such as new road densities and flow speeds and the number of vehicles traversing and reaching the end of the links. Afterwards, a mass or vehicular balance is performed at the nodes, and the number of vehicles moving through each node from one link to another is calculated. Thus, a time step typically involves the calculation of the dynamics on all links followed by a vehicular balance at each node. If the time steps are chosen appropriately, the evacuation process can be modelled over time by stepping through each time step individually.

As can be seen, the model essentially involves two calculational procedures: a dynamical calculation for all links during a time step and a vehicular balance at all nodes at the end of a time step. These procedures are identified as the dynamic link scan and the vehicular balance node scan.

Dynamic Link Scan. During the link scan, the traffic volume is calculated from the beginning condition on each link. The network shown in Fig. 5 illustrates each link. A link can have one or more lanes (defined by $NL_{l_{mn}}$) where l_{mn} is the link designator as discussed for Fig. 5. To simplify writing the appropriate relations and equations, the nomenclature will be link l instead of l_{mn}, in which l represents a number corresponding from one to the total number of links, n_l.

Thus, the number of traffic lanes for link l is NL_l. The length of link l in miles is LD_l. The free-flow operating speed on link l is FFS_l, given in miles per hour. The free-flow operating speed is the operating speed of vehicles on the link during extremely low traffic densities. The standard capacity of link l is $CS(l)$, given in vehicles per hour. Standard capacity is the maximum number of vehicles that can reasonably be expected to pass over a given section of roadway in 1 h. (These and other parameters are discussed thoroughly in Ref. 2.)

To expand on the model, a few general traffic flow relationships must first be explained. The three key link parameters are

F = rate of flow (vehicles/h),

S = average link speed (mi/h), and

D = link density per lane (vehicles/mi/lane).

The parameters are related via the expression

$$F = S \cdot D \quad ,$$

which essentially says the number of vehicles traveling on a link is equal to the average speed multiplied by the link density. These parameters are macroscopic measures of a traffic flow. Although the previous expression seems to suggest that a given rate of flow may occur at numerous combinations of speed and density, this is not the case. In practice, only a limited number of combinations will occur since there may be additional relationships between F and S, F and D, and S and D which control these combinations. Figure 6 graphically illustrates the general form of these three relationships. (References 7 and 8 give an in-depth discussion of these relationships.)

During the link scan, the density on each link is calculated first, where t is equal to time. For illustration, t is taken to represent time at the end of a time step. The link density per lane is

$$D_l(t) \frac{L_l(t)/NL_l}{LD_l - LQ(t)} \quad ,$$

where

$V_l(t)$ = number of vehicles moving on link l, and

$LQ_l(t)$ = length of the queue of vehicles stopped at the end of link l because of a bottleneck (mi).

LQ_l is the result of traffic bottlenecks due to flow restrictions at the end of a link. For example, two links may end at a node with only one exit

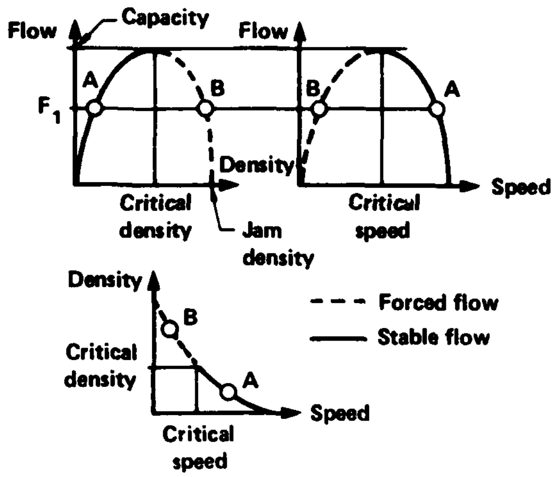


Figure 6. Relationship between speed, flow, and density.[7,8] Flow rate F_1 occurs under two different flow conditions, A and B.

link. Thus, vehicles may be required to stop at the ends of the input links because of a flow restriction. LQ_l is the length of such a queue of vehicles at the end of link l. If $VQ_l(t)$ is the number of vehicles in the queue and VL is vehicle length in miles, then

$$LQ_l(t) = VQ_l(t) \cdot VL \quad .$$

The average link speed is calculated in the EVACD model by assuming a parabolic relationship between the link flow and density, shown in Fig. 6. The jam density per lane DJ_l illustrated in Fig. 6 can be approximated as

$$DJ_l = \frac{4CS_l}{FFS_l} \quad .$$

Therefore, the average link speed is defined as

$$S_l(t) = FFS_l\left(1 - \frac{D_l(t)}{DJ_l}\right) \quad ,$$

and the link rate of flow becomes

$$F_l(t) = D_l(t) \cdot S_l(t) \cdot NL_l \quad .$$

The number of vehicles reaching the termination node or the end of the queue during the interval is defined as

$$VL_l(t) = F_l(t) \cdot T \quad ,$$

where T = time step interval (h).

$VL_l(t)$ is constrained to be equal to or less than the number of vehicles initially on the link, or

$$VL_l(t) \leq V_l(t) \quad .$$

The vehicles remaining on the link, VR_l, are defined to be

$$VR_l(t) = V_l(t) - VL_l(t) \quad .$$

After the time step, the link may still have room to add additional vehicles during the next scan. This excess vehicular capacity VE_l is calculated by assuming that the added vehicles will essentially bring the link density D_l, to the jam density DJ_l,

$$\frac{VE_l(t)}{[LD_l - LQ_l(t)] \cdot NL_l} \quad ,$$

or

$$VE_l(t) = [LD_l - LQ_l(t)] \cdot NL_l[DJ_l - D_l(t)] \quad .$$

The vehicular balance node scan follows completion of the dynamic link scan.

Vehicular Balance Node Scan. The vehicular node scan calculates the number of vehicles flowing in and out of each node, assuring a vehicular balance over time. The process starts by summing up all potential vehicles that may use a node,

$$VN_{n_l}(t) = VQ_l(t) + VL_l(t) \quad ,$$

where n_l = subscript for node n flow from link l.

Thus, $VN_{n_l}(t)$ is the sum of the end queue of link l plus all vehicles reaching the input link queue or the link termination during the time step.

Next, it is necessary to calculate the fraction of time that traffic flow from an input link to the node can move through the node or intersection, G_l. For cases such as signalized intersections, the value may be defined as

$$G_l(t) = GS_l \quad ,$$

where GS_l = fraction of time for flow (fraction h/h).

For cases where there is no signalized intersection, the fraction of flow time for a link is assumed to be proportional to its potential flow to those of all other input links to node n,

$$G_l(t) = \frac{VN_{nl}(t)/NL_l}{\sum_k VN_{nk}/NL_k} \quad ,$$

where k = all input links to node n.

The approach capacity of each input link, CA_l, is calculated to be

$$CA_l(t) = G_l(t) \cdot CS_l \quad .$$

Next, it is necessary to determine the number of vehicles passing through the node into each output link. The calculational procedure is as follows. First, the number of vehicles leaving each input link is calculated assuming no node restraints.

$$VI_l(t) = T \cdot CA_l(t)$$

and is restricted to be equal to or less than $VN_{nl}(t)$, the number of vehicles available for leaving the link. Thus,

$$VI_l(t) = VN_{nl}(t), \text{ if } T \cdot CA_l(t) < VN_{nl}(t) \quad .$$

The flow volume received by each output link from node n is ascertained by first calculating a preference for traffic to take the link. We assume that the preference is proportional to a previously agreed upon preference factor multiplied by the average link speed,

$$P_{lj}(t) = \frac{PF_j \cdot S_j(t)}{\sum_k PF_k \cdot S_k(t)} \quad ,$$

where

$P_{lj}(t)$ = preference factor from input link l to output link j (fraction),
PF_j = inputted preference factor for output link j regardless of input link, and
k = all output links to node n.

The vehicles received by output link j, VO_j are defined as

$$VO_j(t) = \sum_k VI_k(t) \cdot P_{kj}(t) \quad ,$$

where k = all input links to node n.

This number must be less than or equal to the capacity of output link j multiplied by time step T and cannot exceed $VE_j(t)$, the excess vehicular capacity on the link. This can be expressed as

$$JO_j(t) = \min\,[VO_j(t);\ T \cdot CS_j;\ VE_j(t)] \quad ,$$

where min = take the minimum of all the quantities.

Therefore, the vehicles VT_{lj} transferred from input link l to output link j are

$$VT_{lj}(t) = VI_l(t) \cdot P_{lj}(t) \frac{VO_j(t)}{\sum_k VI_k(t) \cdot P(t)} \quad ,$$

where k = all input links to node n.

The vehicular node scan is complete following this calculation. The process continues with another dynamic link scan for the next time step where

$$V_l(t) = VR_l(t - T) + \sum_k VT_{kl}(t - T) \quad ,$$

where k = all input links to origin node of link l.

Therefore, by time-stepping through the evacuation and performing a dynamic link scan followed by a vehicular balance node scan for each time step, the desired time-dependent results can be calculated.

Calculation of Appropriate Doses

The EVACD model described in this report calculates three specific radiological components for assessing the effect of airborne radioactive releases from a nuclear power generating station. The calculations are contained in subroutine DSCLC. The calculations were performed for a specific set of data:

1. Accumulated dose commitments (mrem) to the thyroid due to ^{131}I inhalation.

2. Accumulated dose commitments (mrem) to the total body due to ^{137}Cs inhalation.
3. Accumulated whole-body dose exposures (mrem) to ^{133}Xe.

For other applications, DSCALC could be modified.

The calculated population doses to the evacuating population were totaled for each time step by adding up the following components:

1. All populations at input or output nodes.
2. All populations at link output queues.
3. All populations traveling on links during the time step.

Geometric considerations in the subroutines LNKSET and NODSET assure calculation of the correct dose additions for each link and each node.

Sample Case and Outputs

The evacuation emergency response model coupling ARAC output was run for a test case for the region surrounding the Rancho Seco NPP, located ~25 mi southeast of Sacramento. The case was set up with three bottlenecks to restrict the flow capacity of certain links. The population of the region within a 10-mi radius of the nuclear power plant is not dense enough to test the capabilities of this model. That is, for the given population and roads surrounding Rancho Seco, the population would be evacuated within about 1 h. A sample problem employing evacuation of a population of 10,304 people on roads with limited traffic capacities is described in Appendices D and E, which detail model parameters, population distribution, and output. These data have enabled us to fully display this evacuation emergency response model on computer graphics terminals.

The EVACD program was developed for use on a VAX-780 in conjunction with a VSV11 color graphics terminal made by Digital Equipment Corp. The graphics package used was GRAFCORE,[9] developed by the Lawrence Livermore National Laboratory. The output of the program consists of three types of displays. The first type appears only once and shows the evacuation zone as a road network. The second type shows the road network with the isopleths the user wishes to see. The third type is a histogram showing population movement.

In the displays thick lines denoting queues build up behind the nodes. During later time steps these same queues gradually shrink. The displays show the growth and dispersion of the radioactive plume (represented by the dose isopleths). The user can see which nodes and links intersect the path of the plume and how the population can be diverted. Growth and shrinkage of nodes and links provide information on the movement of people and on the size of the population at risk from the plume. The histograms show population movement outward and its slow movement through the rings where the bottlenecks are.

Figure 7 is a black-and-white illustration of the first type of display showing the initial road network, site layout, and evacuation case parameters before evacuation has proceeded. It is the first display available to the user of this model. The reactor building and site boundary are displayed in orange in the center of the screen; a lake within the site is cyan. The axes show the distance in mi from the reactor building. Two circles in green are at radii of 10 and 15 mi, respectively. The road network is displayed in yellow and the small circles or nodes are in orange. The road network ends beyond the 10-mi radius, at which distance the population is assumed to be evacuated.

At the beginning of the problem, all road thicknesses and node circles are the same size. As the evacuation proceeds, the thickness of the road may increase indicating a queuing, and the circles increase in size indicating a bottleneck of the population at these nodes. In the upper left-hand portion of the screen are the warning time of 0.25 h required to evacuate, the population time of 0 h needed to evacuate after the warning is given, and the total population contained within a 10-mi radius of the plant. The user, of course, has the option of varying the warning time and the preparation time if other numbers are more appropriate to an exercise or real accident.

In the second type of display, the user is prompted for the particular nuclide whose isopleths he wishes to see. These isopleths are displayed over the existing road network. The user is then asked if he wants to see isopleths for a different nuclide. If the answer is yes, the user chooses the next nuclide to be displayed and the previous plot is replaced. If the answer is no, the display disappears and the histogram plot is displayed.

The second type of display is similar to the first but changes dynamically at each dispersion

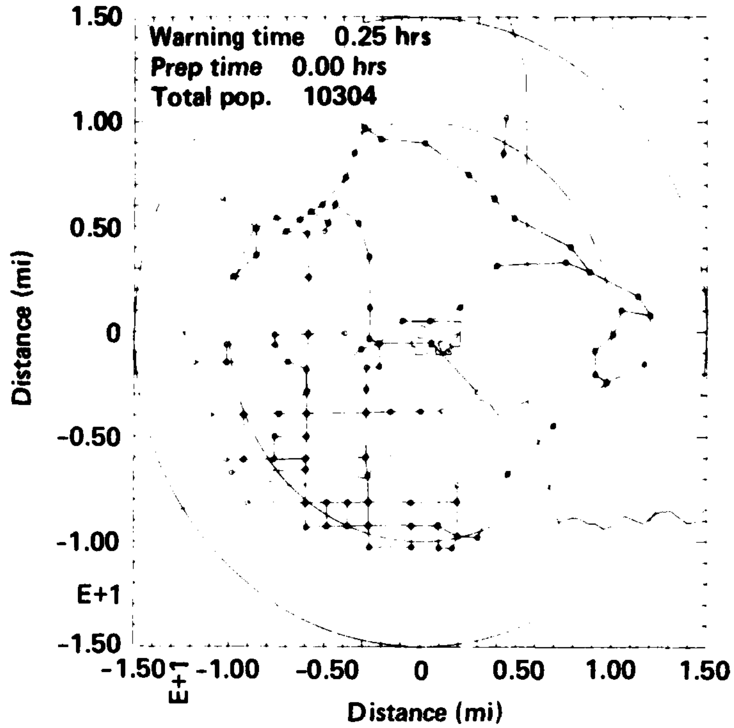


Figure 7. First type of display of the EVACD program showing initial road network, site layout, and evacuation case parameters.

update time as the evacuation proceeds. Orange circles are drawn around each input node. Gold circles are drawn around each output node to indicate the number of people evacuated. Links are redrawn as thicker lines to indicate road density, and queues are drawn in orange. In addition, the user can request that dose isopleths be added to the display.

Figure 8, the second type of display (road network-isopleth), shows dose isopleths due to ^{131}I inhalation 0.25 h following release. The program counts zero people on the road network since the population has not yet begun to move. Four isopleths are displayed, corresponding to the four contour levels read from the input file ACLEVS.DAT. These levels are typed in the top right corner of the screen. On the color graphics terminal the isopleths are drawn in varying shades of magenta, with the darkest shade indicating the highest dose. The values of the levels shown on the screen are also typed in shades of magenta corresponding to the appropriate isopleth.

Further information in the top left corner of the display includes time since release, the population entering the road network at the time of evacuation, the population leaving the road network at that time, and the total fraction of the population evacuated since the release.

The third type of display occurring at each dispersion update is a population histogram showing the number of people presently in 10 rings around the site. The rings are 1-mi wide, i.e., from 0–1 mi, 1–2 mi, 9–10 mi. A bar showing the number of people evacuated beyond 10 mi is also displayed. Figure 9 (a and b) is an example of the second and third types of displays, where Fig. 9a shows the desired isopleths at 0.50 h, and Fig. 9b is the corresponding histogram. In addition to the time and population information in the top left corner of the histogram, accumulated population doses *for* ^{131}I, ^{133}Xe, and ^{137}Cs appear in the top right corner. These values are calculated as described in "Subroutine DSCALC."

Figures 10 through 21 represent a black-and-white version of the color graphics output from a

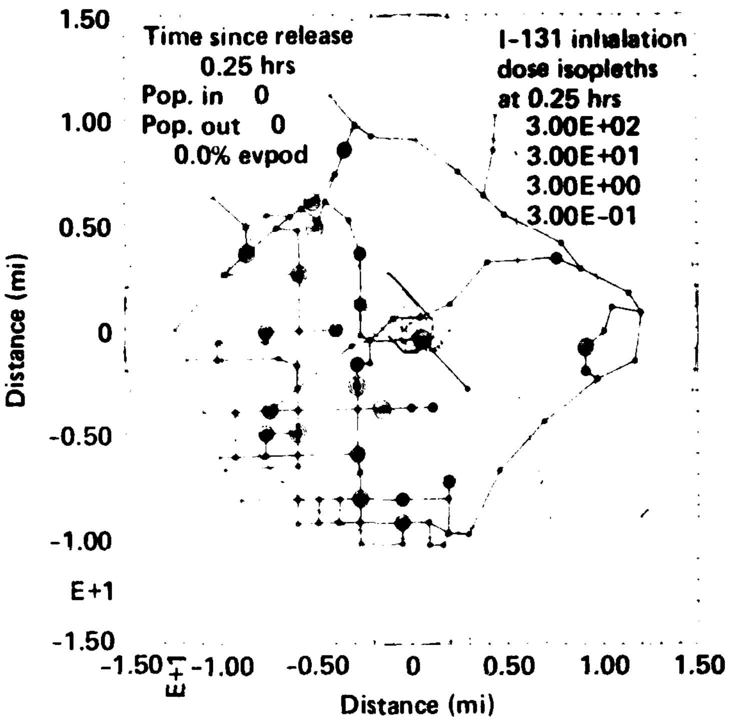
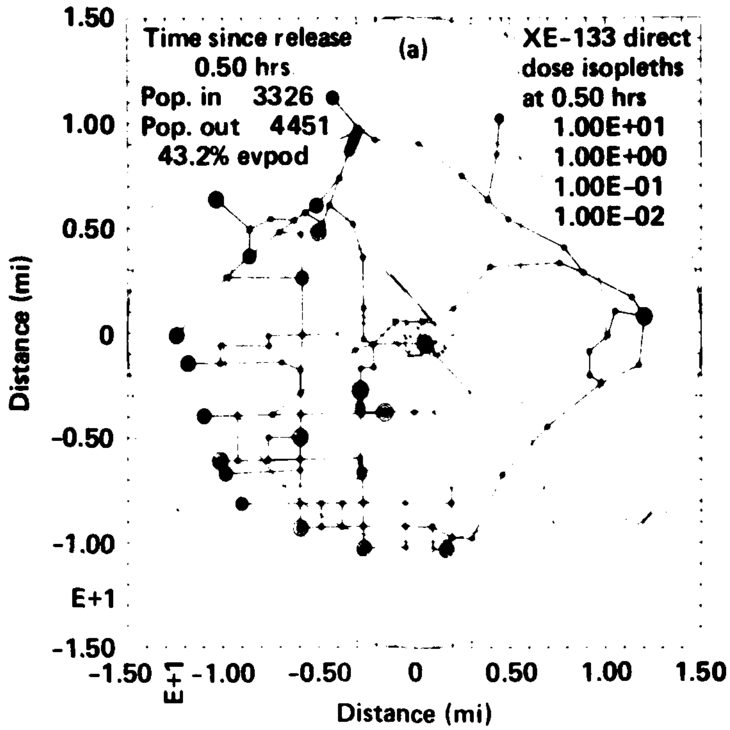


Figure 8. Second type of display of the EVACD program showing ^{131}I inhalation dose isopleths at 0.25 h (15 min) following release. In this type of display the user requests specific isopleths to be shown.

sample execution of the EVACD program, showing in sequence (in sets of road network-isopleth and corresponding histogram displays) the evacuation of the population through the road network every 15 min up until 3 h after the release, when 85% of the population is evacuated. Isopleth displays for ^{131}I were requested at every dispersion update, while isopleth displays for ^{133}Xe and ^{137}Cs were requested at every third dispersion update. The user of the program has the option of skipping any of these sets or backtracking to help in the decision making. At each display of the road network, the user has the option of deploying the radiation isopleths for ^{131}I, ^{133}Xe, ^{137}Cs, or none at all.

The first set of displays (road network-isopleth and corresponding histogram) in Fig. 10 shows the evacuation 0.75 h after the evacuation has started. In the central portion of the road network-isopleth display, isopleths of ^{137}Cs inhalation dose rates (mrem) extend from the inner contour of 0.01 mrem to the outer one of 1×10^{-5} mrem. These contours spread to the upper left-hand portion of the display, intersecting personnel evacuated along these routes. Thus, emergency response personnel may decide to change their evacuation plans based on these factors. The circles outside the 10-mi radius have expanded proportionally to the population numbers evacuated to that node. Data in the upper left-hand corner inform the user that 1042 people are still entering the road network, 6808 people have left the road network, and a total of 66.1% have already been evacuated outside the 10-mi radius.

Note the large circles surrounding some of the nodes in the left-central portion of the display. A thickening of the road network is also visible along the lower left-central and upper left-central portion of the graph. The large circles and the thickening relate to the corresponding histogram which shows the number of people still being evacuated as a function of distance from the plant and those already evacuated 45 min after evacuation began. The bottlenecks between 8 and 10 mi



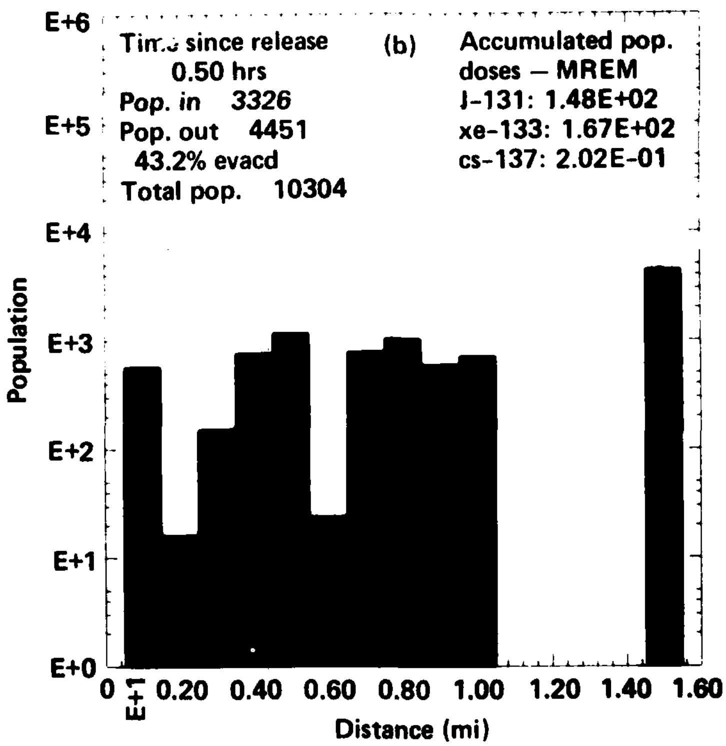
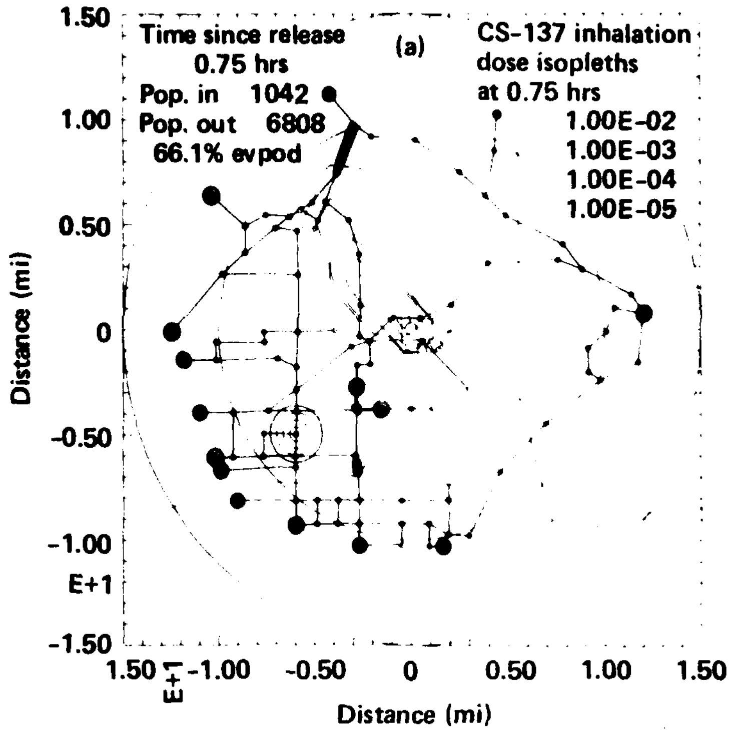


Figure 9. Set of (a) road network-isopleth and (b) corresponding histogram displays at 0.50 h. The histogram, depicting population movement, is the third type of display of the EVACD program.



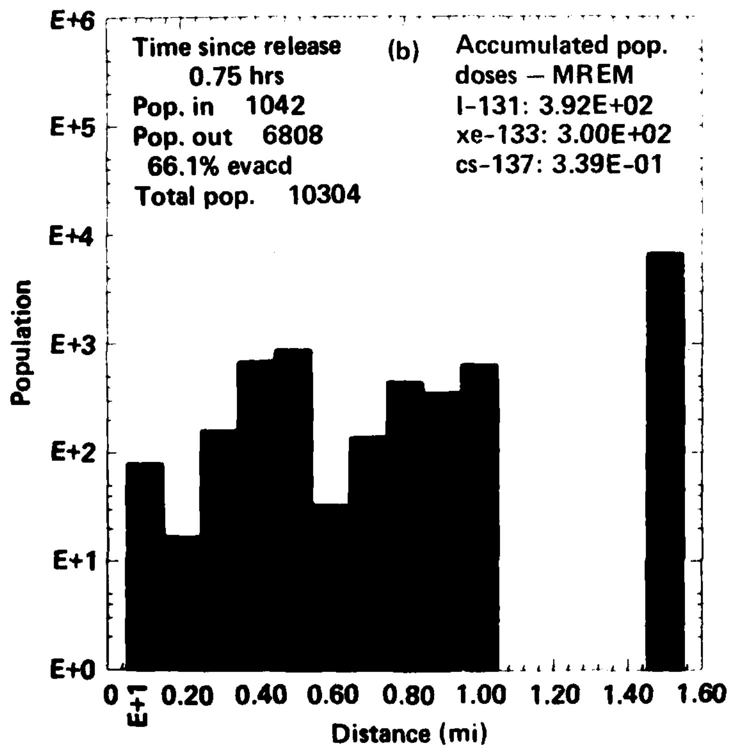


Figure 10. (a) Road network-isopleth display and (b) corresponding histogram of a test case for the region surrounding the Rancho Seco Nuclear Power Plant showing evacuation of the population through the road network at 0.75 h. Figures 11 through 21 continue the sequence showing evacuation every *15 min up until 3 h after the* release, when 85% of the population is evacuated. This sequence is a black-and-white version of the color graphics output from a sample execution of the EVACD program.

and 3 and 5 mi can be seen now on the histogram and are related to the circles seen in the corresponding road network-isopleth display. The number evacuated is shown in the upper left-hand corner of the histogram and is directly related to the circle outside the 10-mi radius. Total accumulated population doses are displayed in the upper right-hand corner.

In this particular case, the Rancho Seco test case, the sequence is continued until the program terminates with 92.6% of the population evacuated (see the final set of displays in Fig. 21). The user has the option of stopping this program at a preset particular percentage of population evacuated or at any time.

In summary, information is available to the user as a function of time to assist in either training sessions or an actual emergency response. At the beginning of an accident and for every 15 min of simulated time thereafter, the user may do the following:

- View a colored map indicating the road network and the number of individuals within a 10- and 15-mi radius of the accident at the NPP.
- Display dose contours for ^{131}I, ^{133}Xe, and ^{137}Cs overlayed on the colored map.
- Display a histogram showing the number of people still within the evacuation zone, those evacuated, and accumulated population doses.
- Determine directly from the color graphics displayed whether a bottleneck exists in evacuating individuals along a particular clogged road.
- Determine directly from the color graphics and overlayed contours whether a particular evacuation route(s) intersects the radiation plume endangering individuals being evacuated.
- Skip any of the preceding options or backtrack to further study a particular display.

Suggested Improvements

The EVACD model was developed to demonstrate the feasibility of coupling an evacuation model with a color graphics system to illustrate the useful information available from such a combination. The display of isopleths resulting from an airborne radioactive release using ARAC data to show potential evacuation problems was an integral part of the demonstration. Coupling of the evacuation model with the airborne releases was demonstrated by calculating population doses and dose commitments. The objective of the program was achieved and has enabled improvement of the system. The following are suggestions for improvement to the developed model:

1. Add more interactive capabilities to allow operators running the model to modify road network conditions at each appropriate time step. In other words, the operator should be allowed to insert road blocks, change road preference factors, and similar types of real-time changes.
2. Add more graphics to make the model the basic tool for training emergency procedure personnel. Suggested output would aid in assessing the various evacuation decisions.
3. Generalize the dose assessment routines to cover more cases of a general nature.
4. Refine the road network model to include more specific data, such as road-dependent capacities similar to those found in Ref. 10.
5. Calibrate the model against data for past actual evacuations.
6. Develop a training program using EVACD as the main teaching tool.

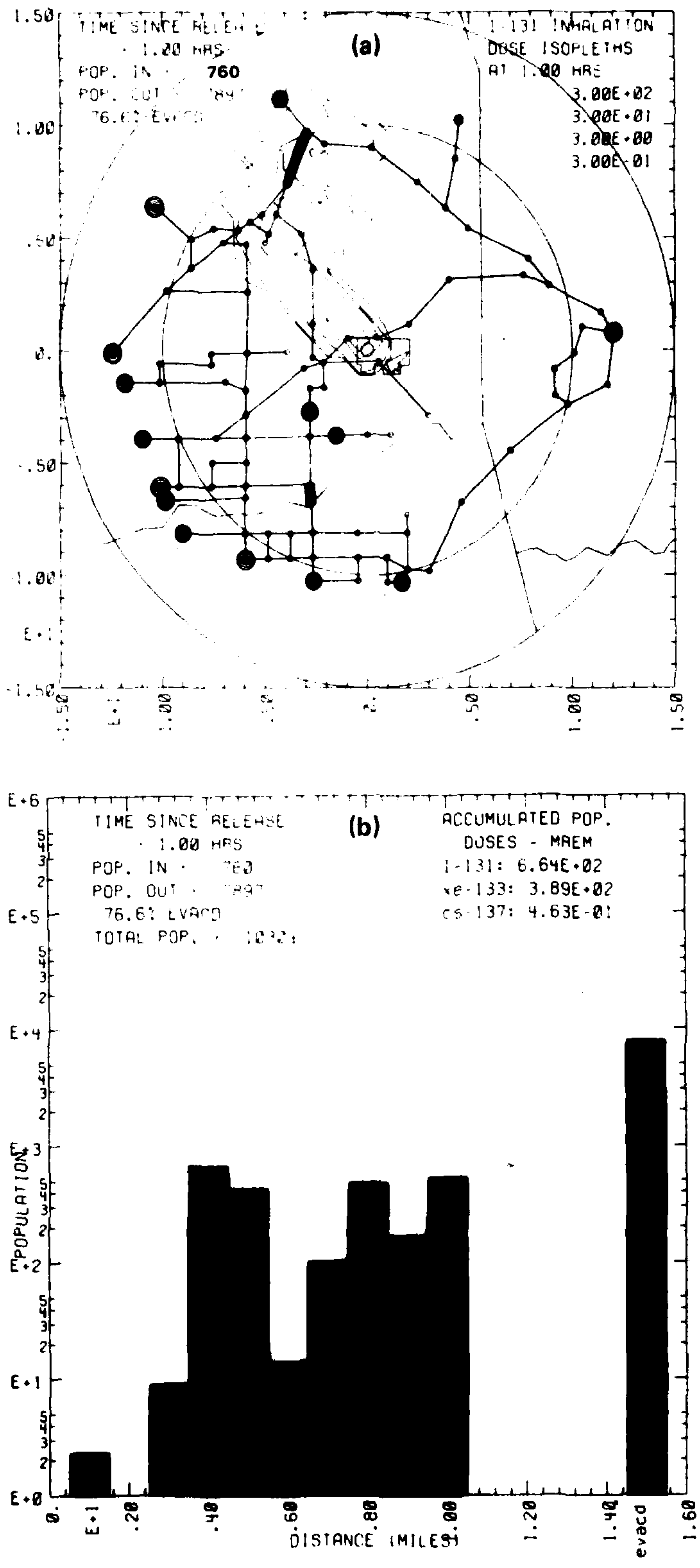
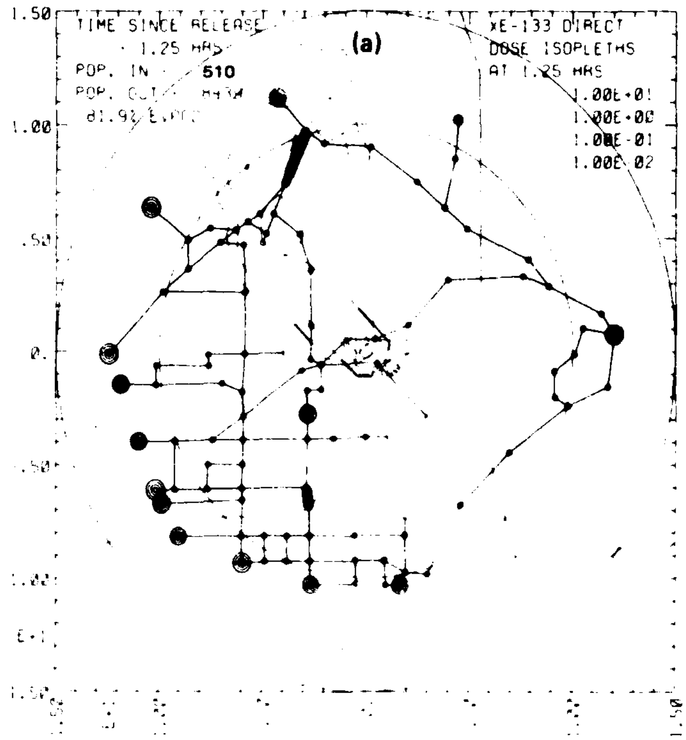
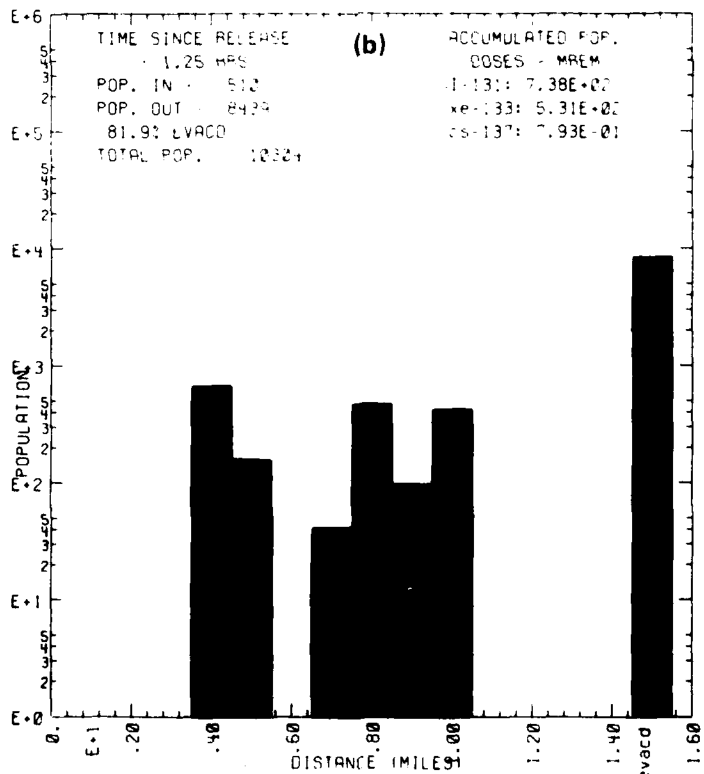

(a)
1.00 HRS
POP. IN 760
I-131 INHALATION
DOSE ISOPLETHS
AT 1.00 HRS
3.00E+02
3.00E+01
3.00E+00
3.00E-01
(b)
TIME SINCE RELEASE
1.00 HRS
ACCUMULATED POP.
DOSES - MREM
I-131: 6.64E+02
XE-133: 3.89E+02
CS-137: 4.63E-01
POPULATION
DISTANCE (MILES)
evacd

Figure 11.



(a)
TIME SINCE RELEASE
1.25 HRS
POP. IN 510
XE-133 DIRECT
DOSE ISOPLETHS
AT 1.25 HRS
1.00E+01
1.00E+00
1.00E-01
1.00E-02



(b)
TIME SINCE RELEASE
1.25 HRS
POP. OUT
81.9% EVACD
TOTAL POP.
ACCUMULATED POP.
DOSES - MREM
XE-133: 5.31E+02
POPULATION
DISTANCE (MILES)
evacd

Figure 12.

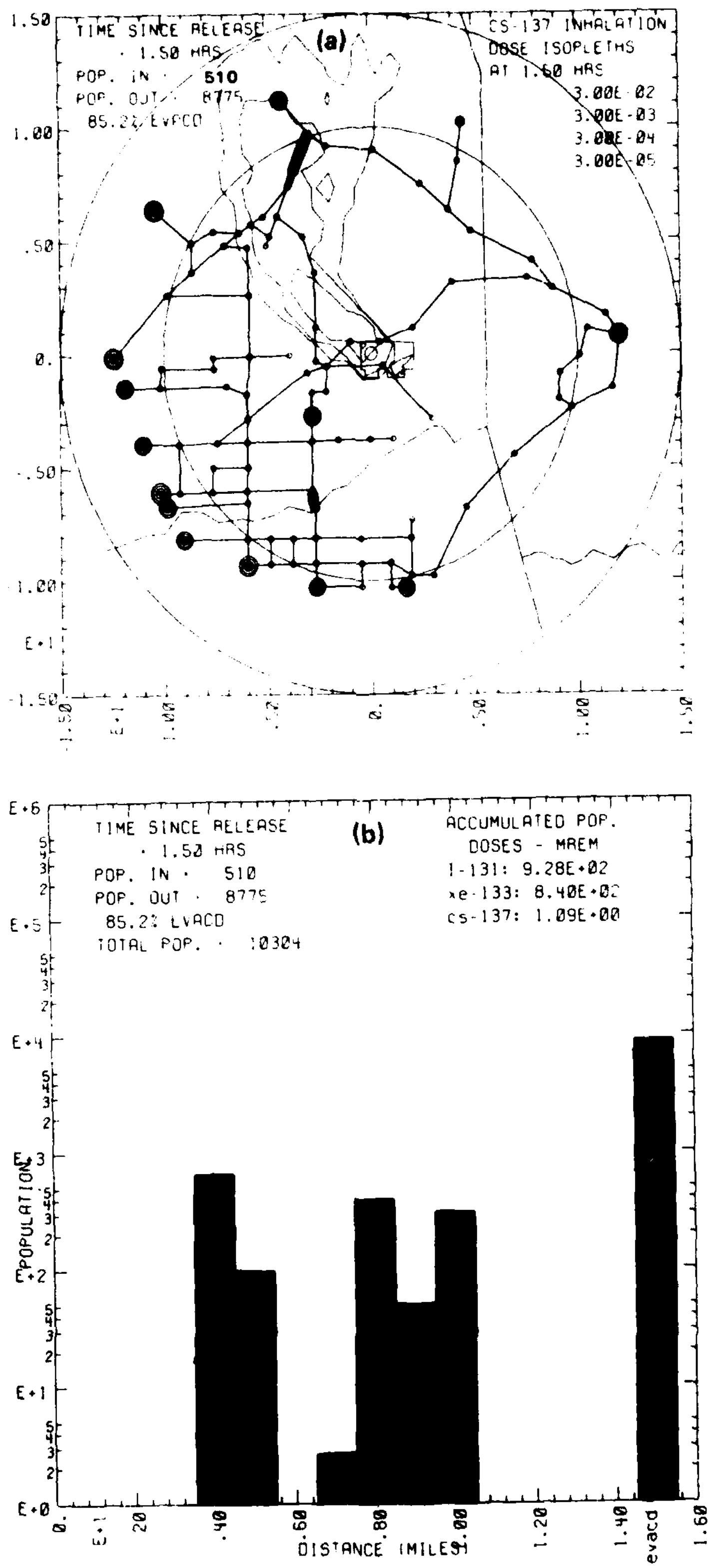
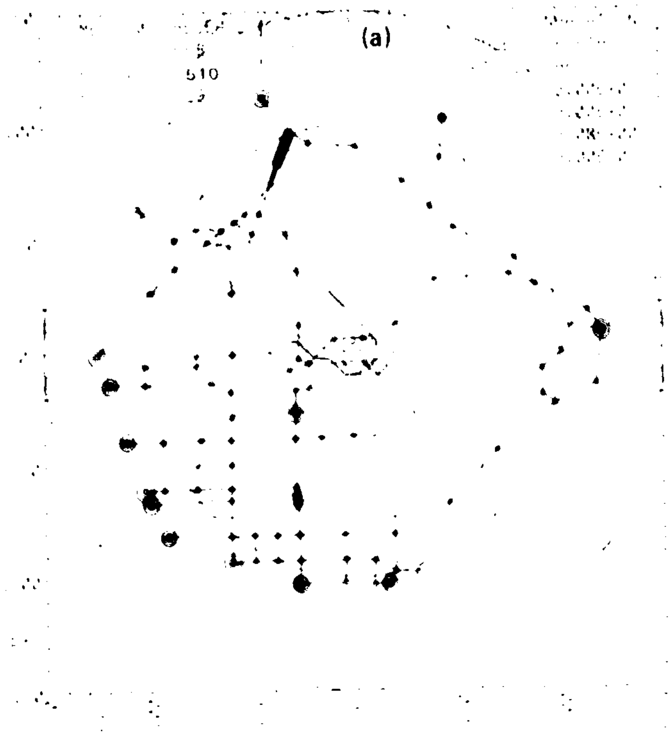

(a)
TIME SINCE RELEASE
1.50 HRS
POP. IN 510
POP. OUT 8775
85.2% EVACD
CS-137 INHALATION
DOSE ISOPLETHS
AT 1.50 HRS
3.00E-02
3.00E-03
3.00E-04
3.00E-05
(b)
TIME SINCE RELEASE
1.50 HRS
POP. IN 510
POP. OUT 8775
85.2% EVACD
TOTAL POP. 10304
ACCUMULATED POP.
DOSES - MREM
I-131: 9.28E+02
XE-133: 8.40E+02
CS-137: 1.09E+00
POPULATION
DISTANCE (MILES)
evacd

Figure 13.

(a)



(b)

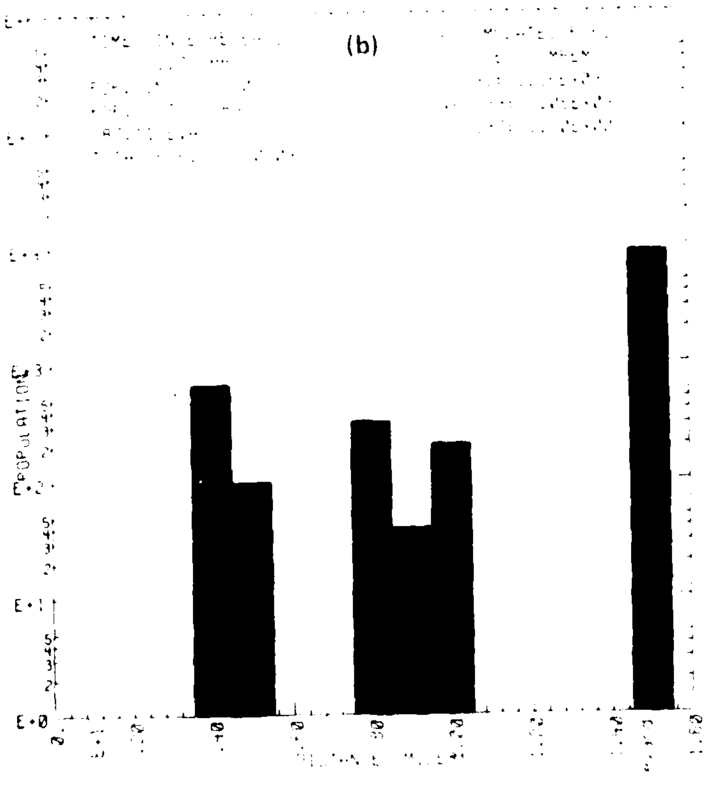


Figure 14.

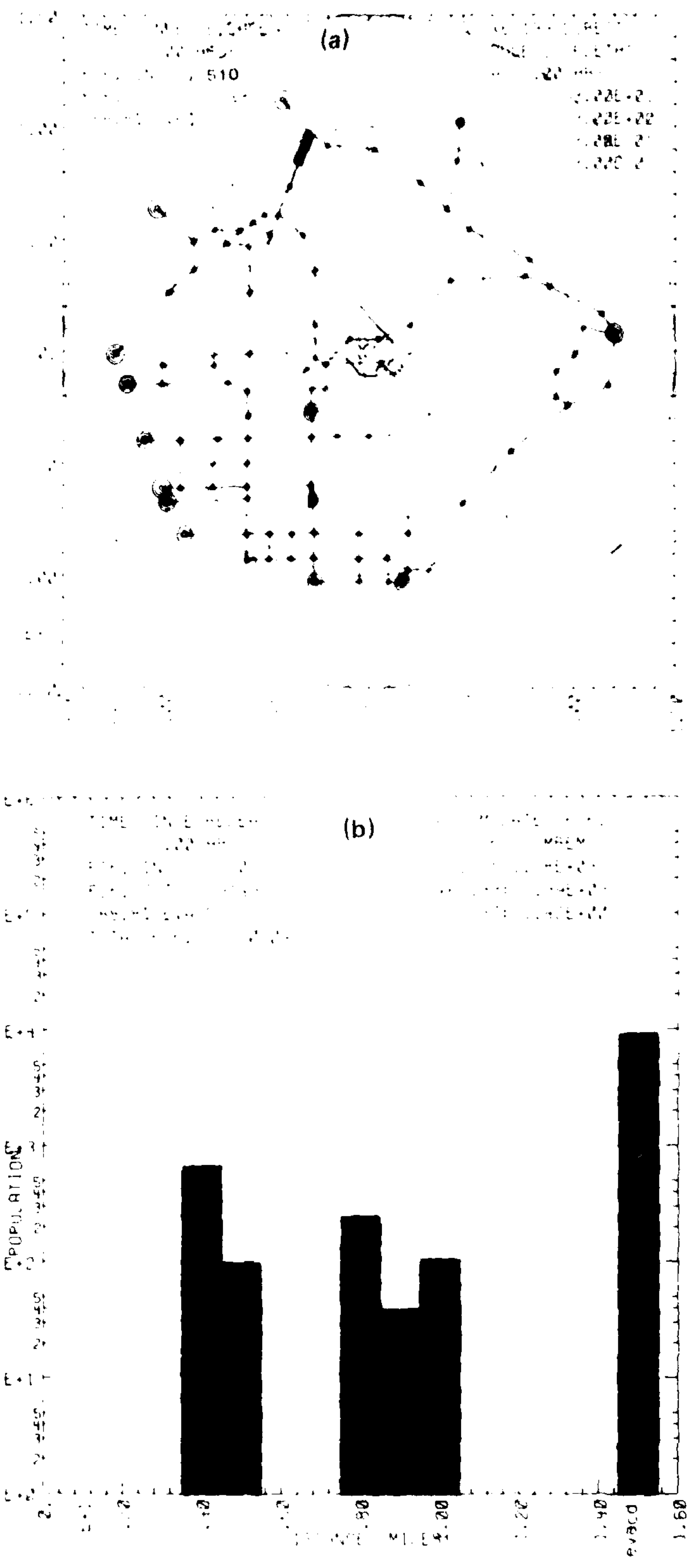


Figure 15.

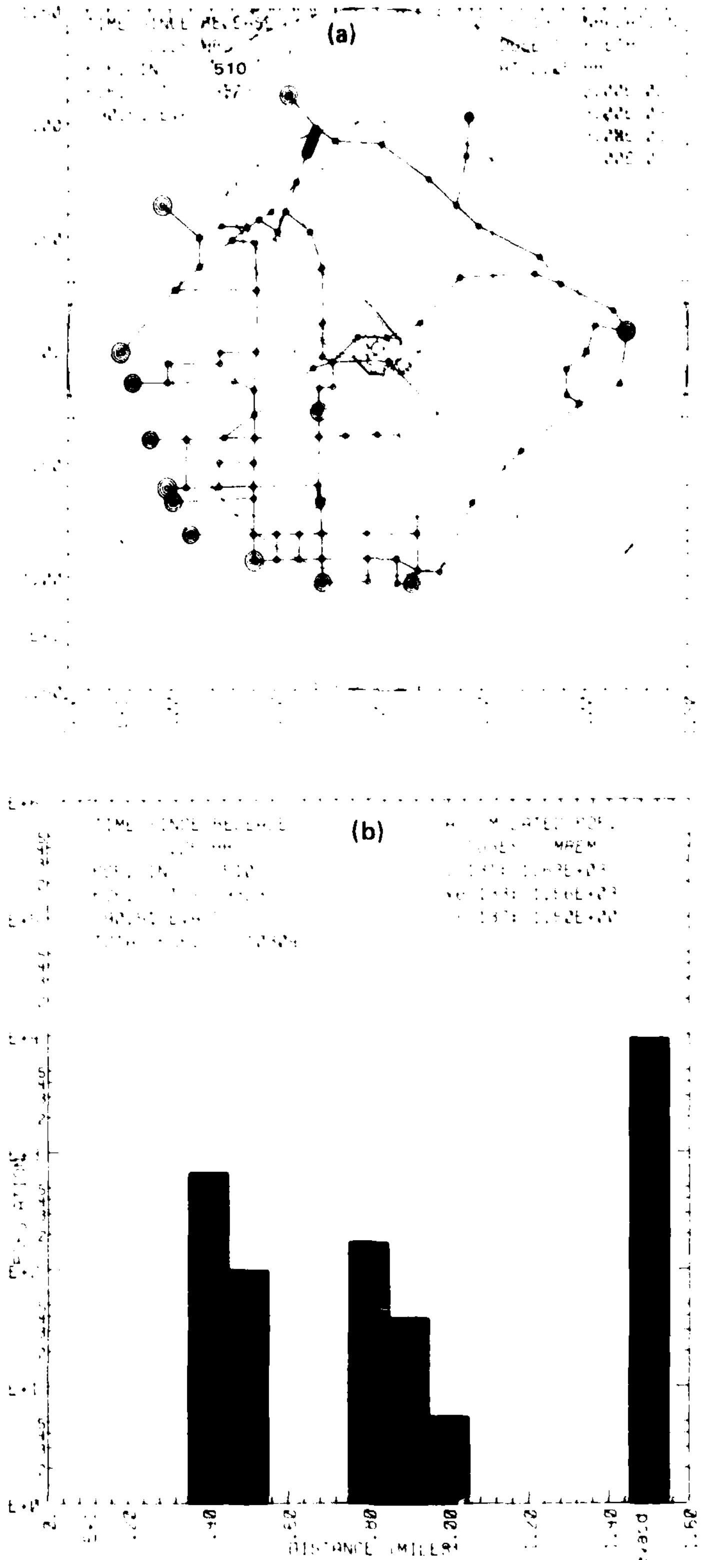


Figure 16.

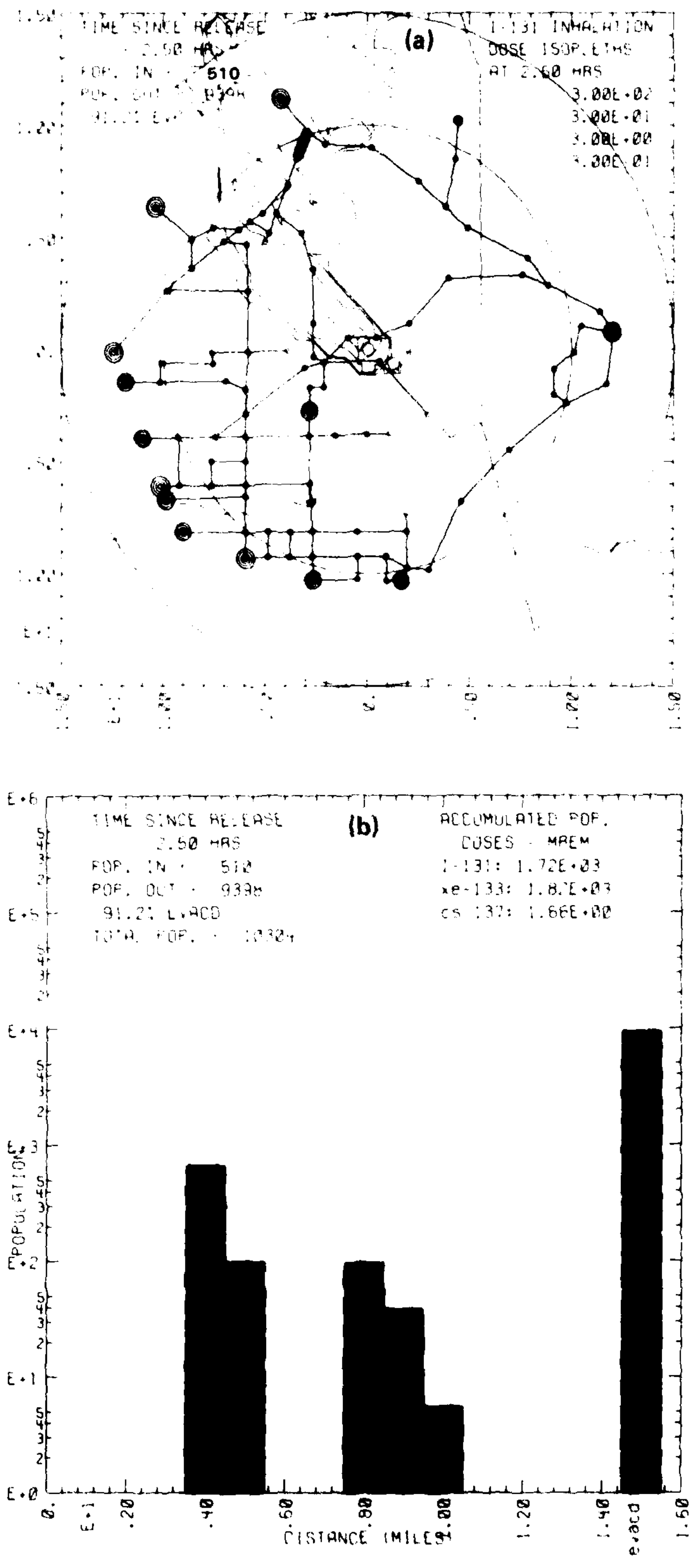
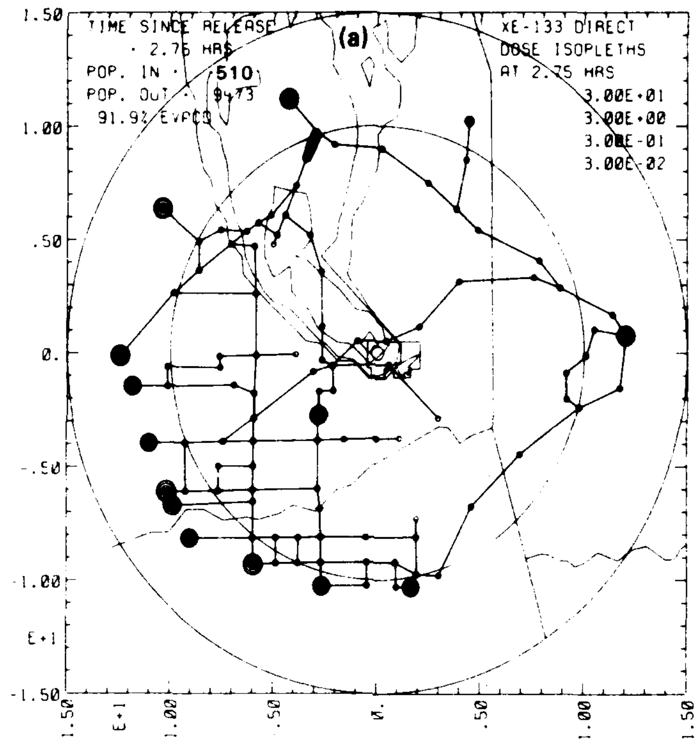
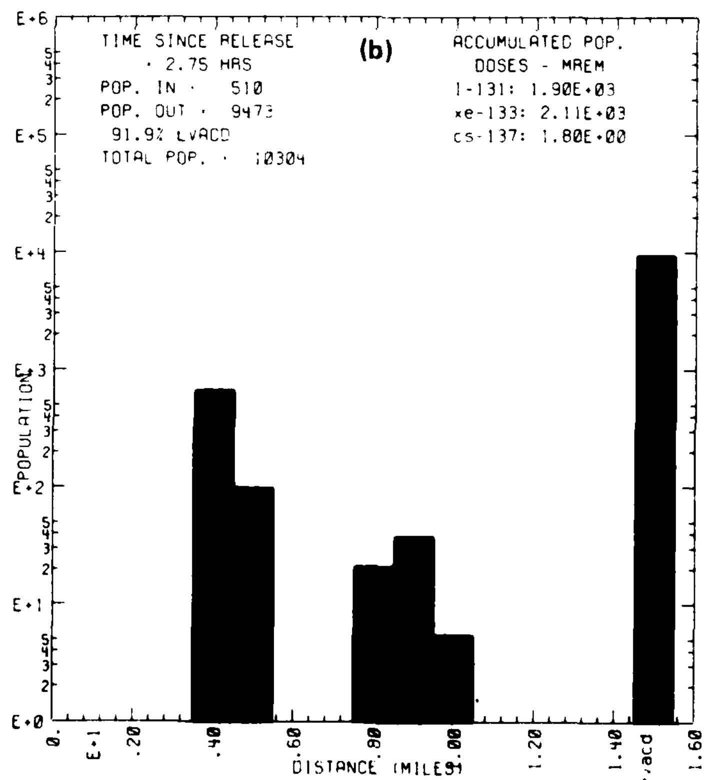

(a)
TIME SINCE RELEASE
2.50 HRS
I-131 INHALATION
DOSE ISOPLETHS
AT 2.50 HRS
3.00E+02
3.00E+01
3.00E+00
(b)
TIME SINCE RELEASE
2.50 HRS
ACCUMULATED POP.
DOSES - MREM
POPULATION
DISTANCE (MILES)
evacd

Figure 17.



(a)
TIME SINCE RELEASE
· 2.75 HRS
POP. IN · 510
POP. OUT · 9473
91.9% EVACD
XE-133 DIRECT
DOSE ISOPLETHS
AT 2.75 HRS
3.00E+01
3.00E+00
3.00E-01
3.00E-02



(b)
TIME SINCE RELEASE
· 2.75 HRS
POP. IN · 510
POP. OUT · 9473
91.9% EVACD
TOTAL POP. · 10304
ACCUMULATED POP.
DOSES - MREM
I-131: 1.90E+03
XE-133: 2.11E+03
CS-137: 1.80E+00
POPULATION
DISTANCE (MILES)

Figure 18.

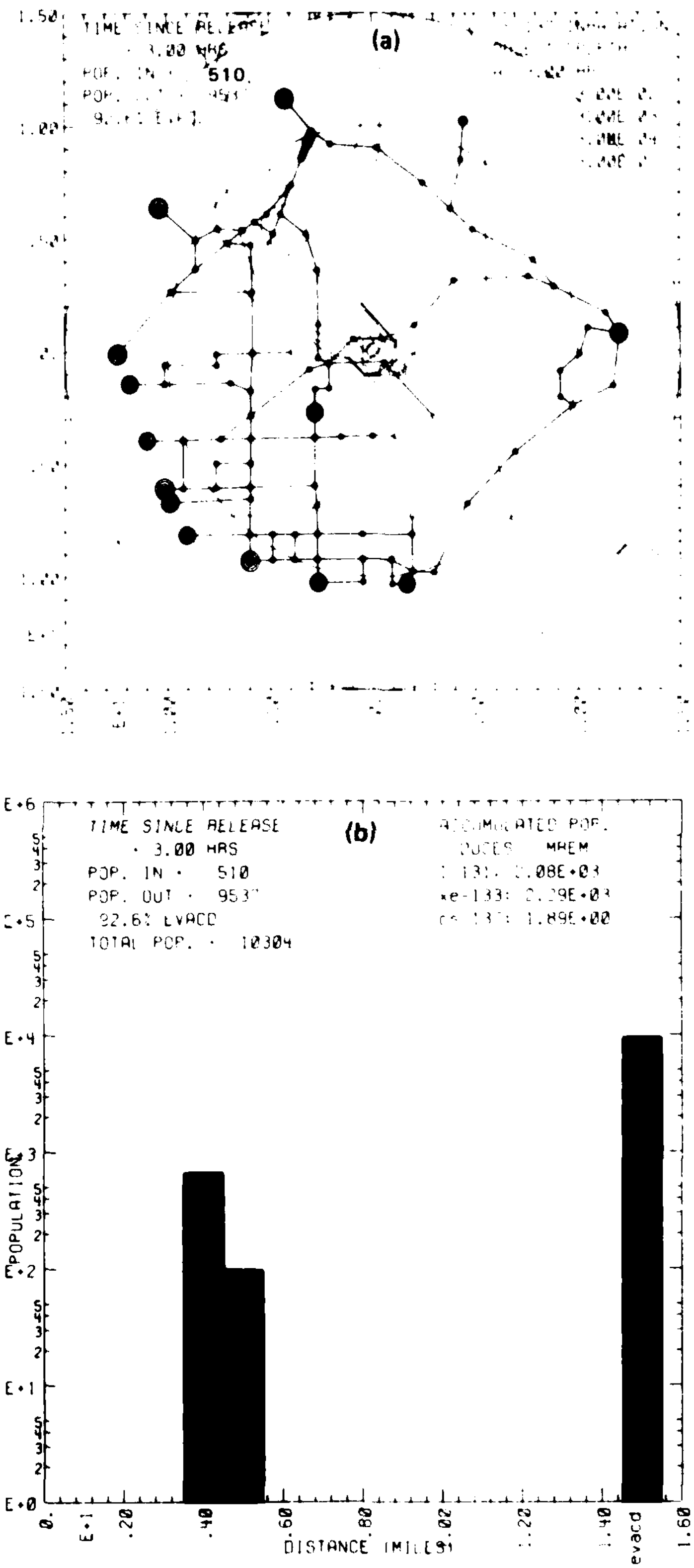
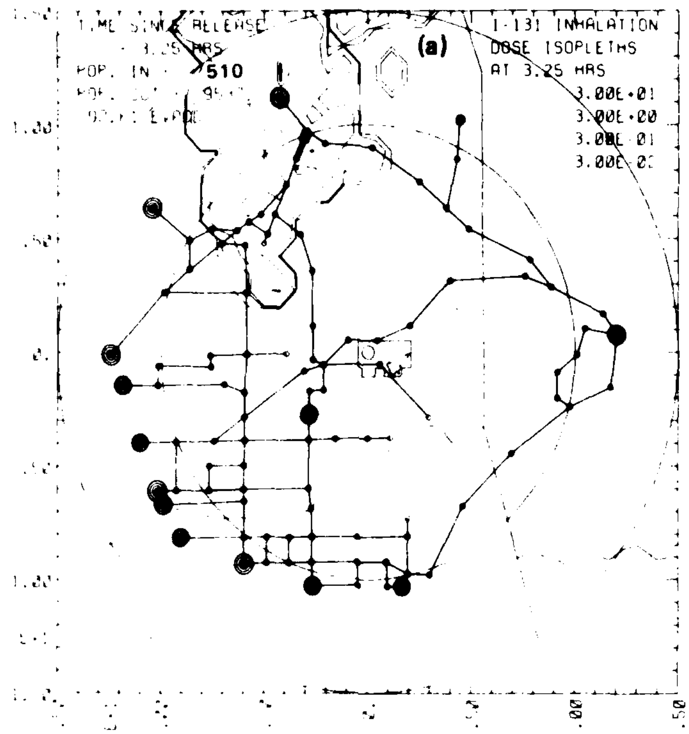

(a)
TIME SINCE RELEASE
510
(b)
TIME SINCE RELEASE
3.00 HRS
POP. IN · 510
TOTAL POP. · 10304
POPULATION
DISTANCE (MILES)
evacd
E+6
E+5
E+4
E+3
E+2
E+1
E+0
.20
.40
.60
.80
1.40
1.60

Figure 19.


(a)
I-131 INHALATION
DOSE ISOPLETHS
AT 3.25 HRS
3.00E+01
3.00E+00
3.00E-01
3.00E-02
1.00
1.50

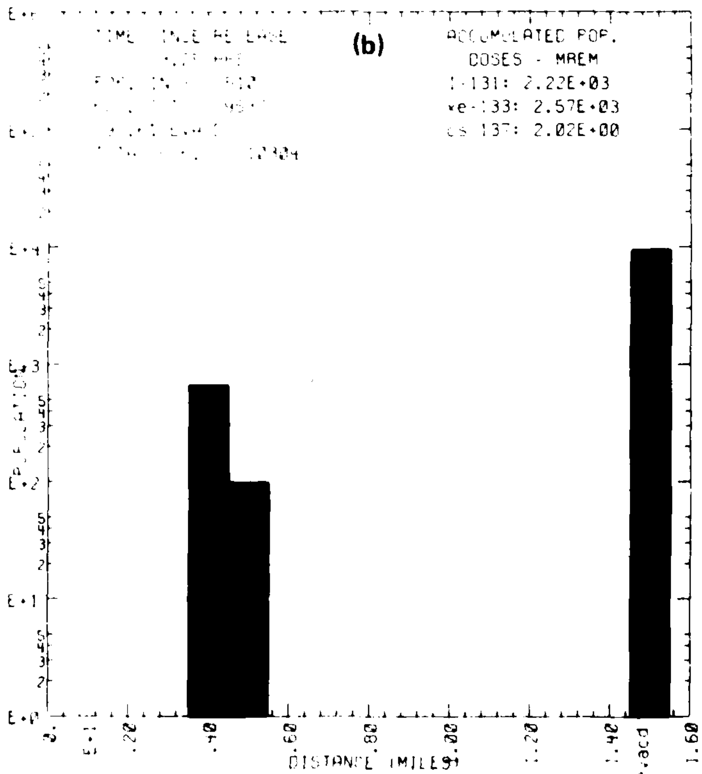
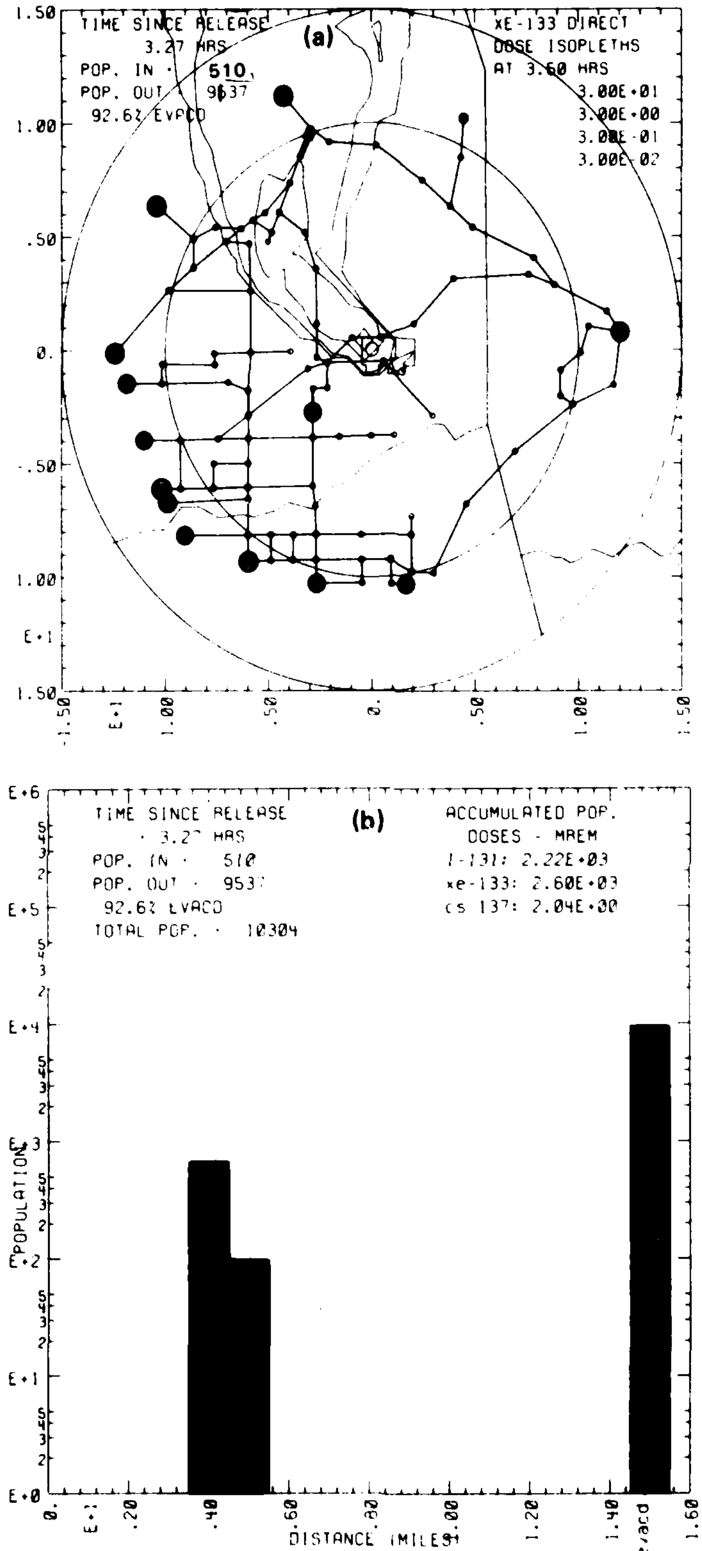

(b)
ACCUMULATED POP.
DOSES - MREM
I-131: 2.22E+03
Xe-133: 2.57E+03
Cs-137: 2.02E+00
DISTANCE (MILES)
.20
.40
.60
.80
1.20
1.40
1.60

Figure 20.



(a)
TIME SINCE RELEASE
3.27 HRS
POP. IN · 510
POP. OUT · 9537
92.6% EVACD
XE-133 DIRECT
DOSE ISOPLETHS
AT 3.50 HRS
3.00E+01
3.00E+00
3.00E-01
3.00E-02
(b)
TIME SINCE RELEASE
3.27 HRS
POP. IN · 510
POP. OUT · 9537
92.6% EVACD
TOTAL POP. · 10304
ACCUMULATED POP.
DOSES - MREM
I-131: 2.22E+03
xe-133: 2.60E+03
cs 137: 2.04E+00
POPULATION
DISTANCE (MILES)
evacd

Figure 21.

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GLE/sg/bp

Appendix A: ARAC Contours

Appendix A contains the full set of ARAC calculated contours for the external, adult, whole-body dose isopleths for ^{133}Xe (Figs. A-1 through A-16); the whole-body, inhalation dose for ^{137}Cs (Figs. A-17 through A-32); and the adult, thyroid, inhalation dose rate for ^{131}I (Figs. A-33 through A-48).

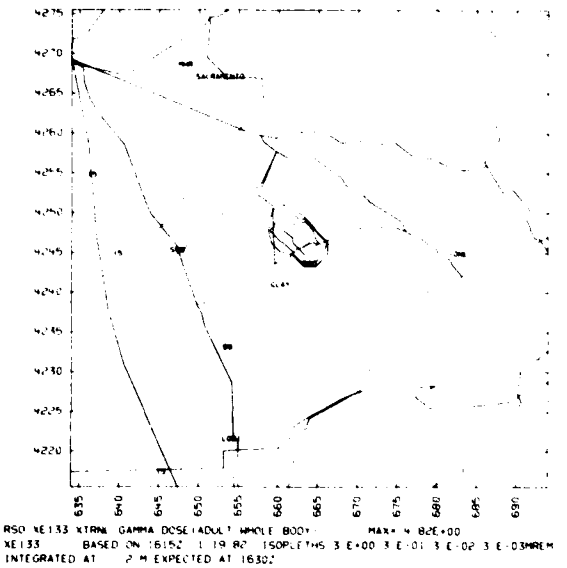


Figure A-1.

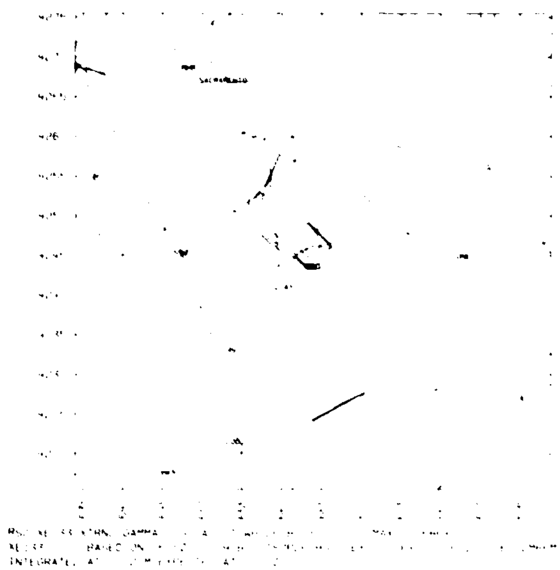


Figure A-3.

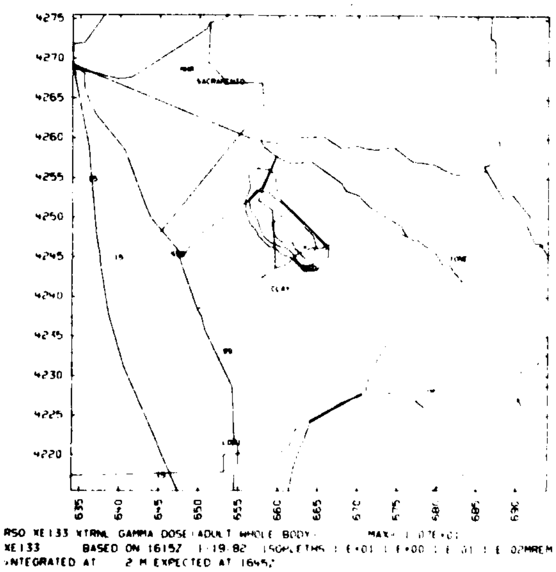


Figure A-2.

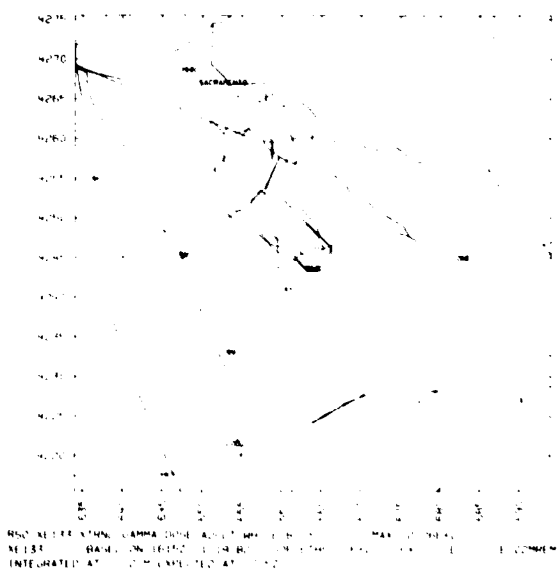


Figure A-4.

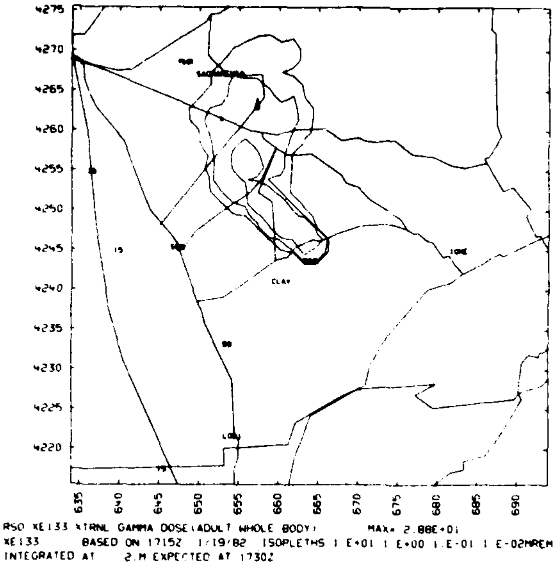
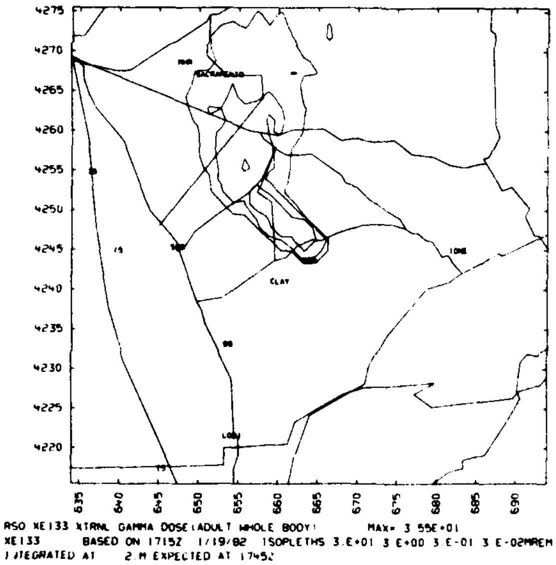


Figure A-5.



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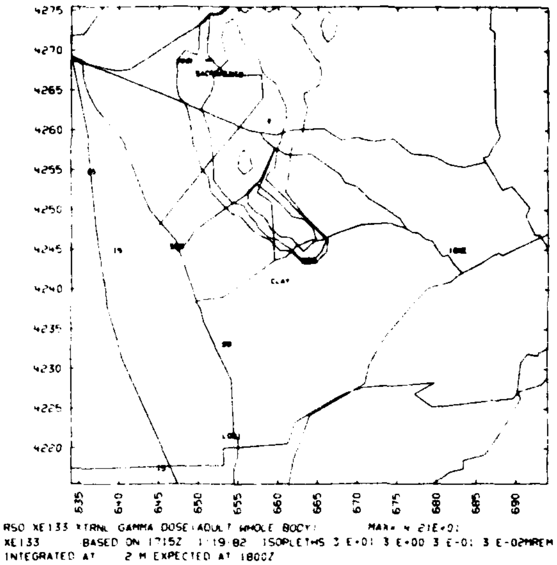

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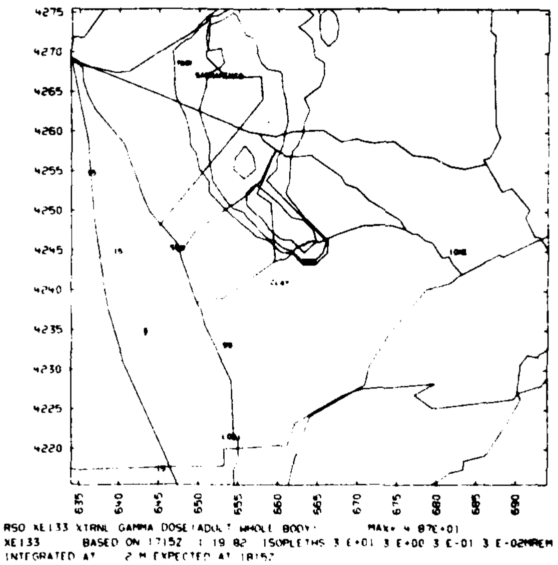

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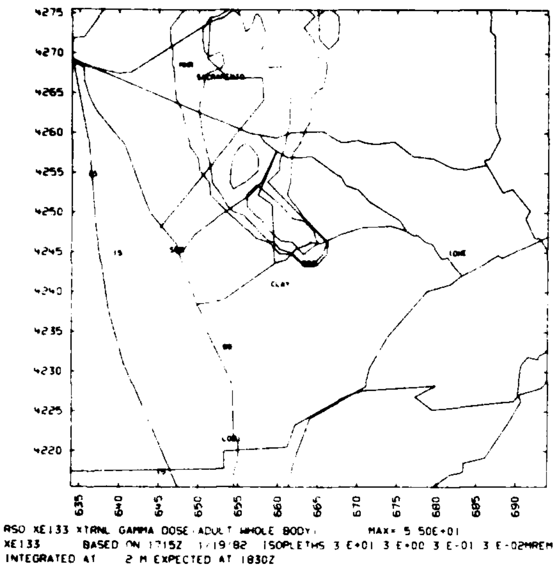

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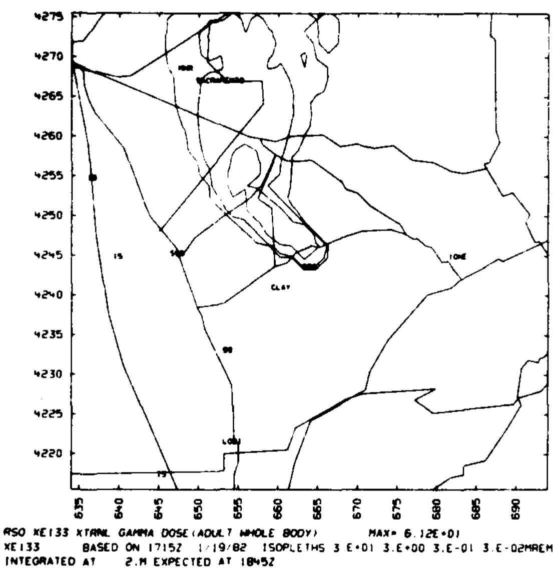

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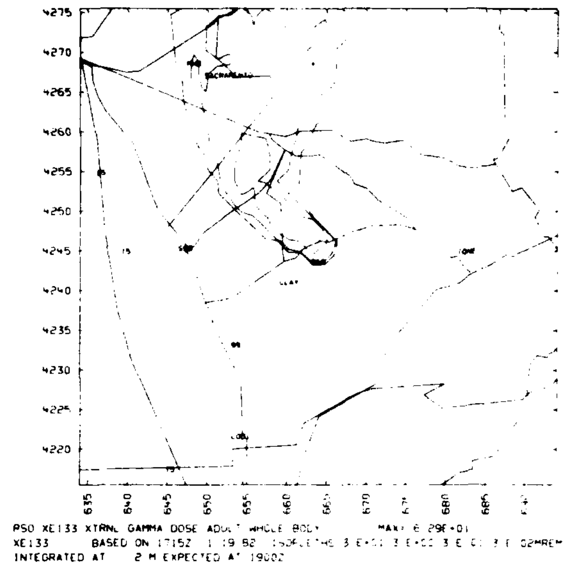

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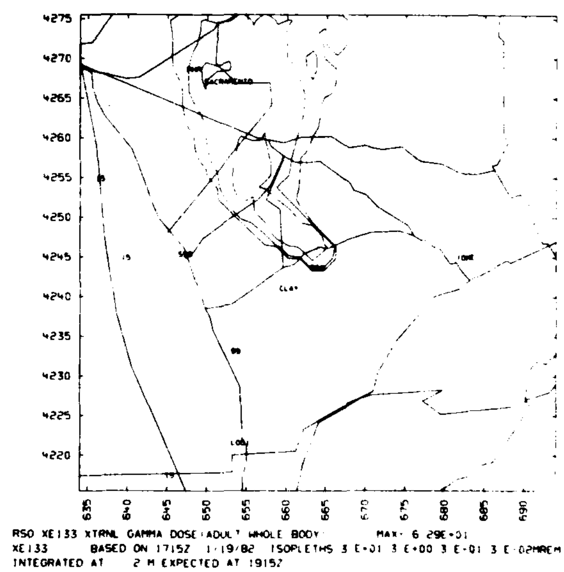

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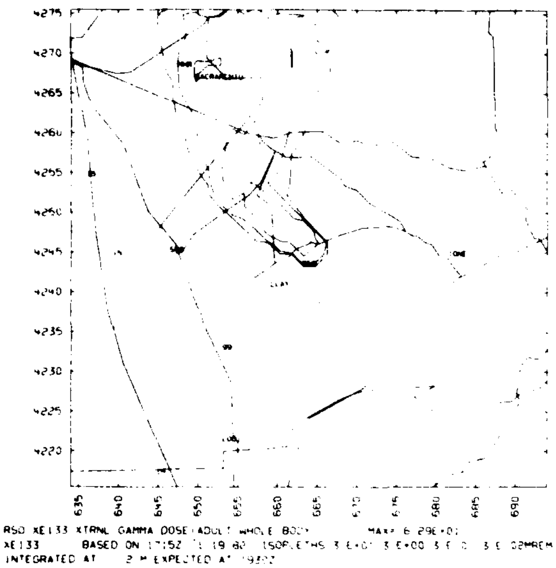

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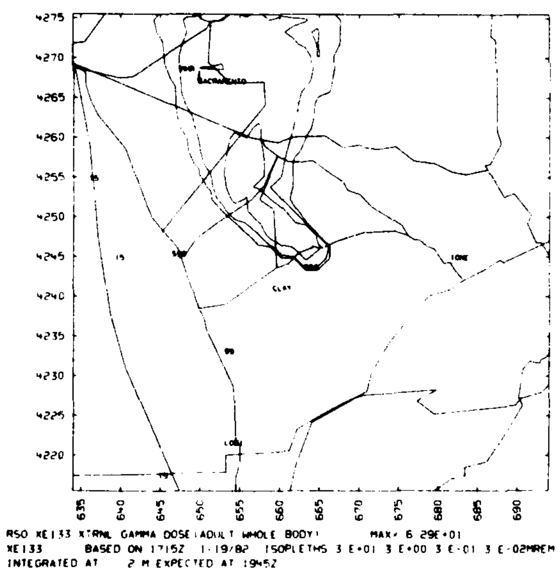

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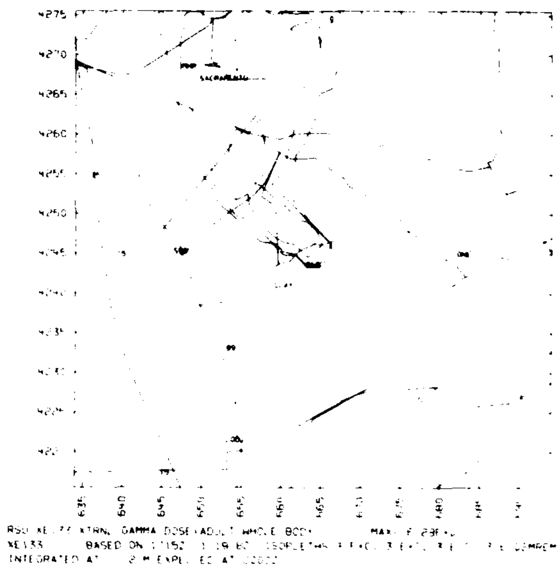

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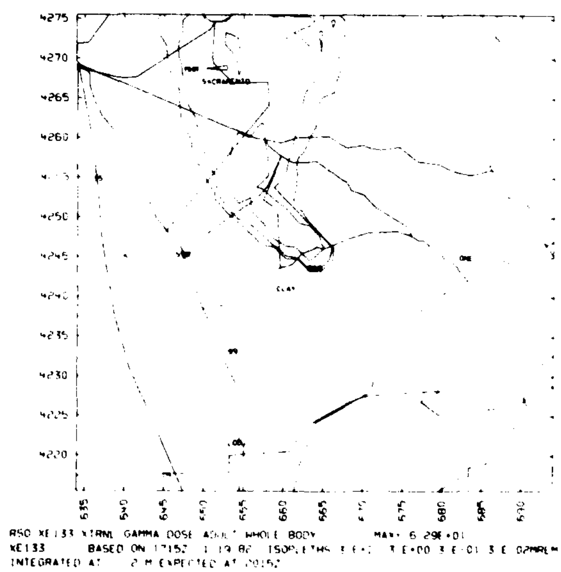

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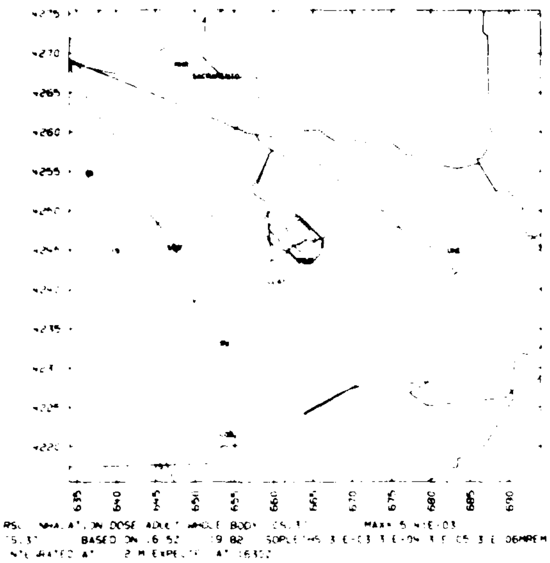

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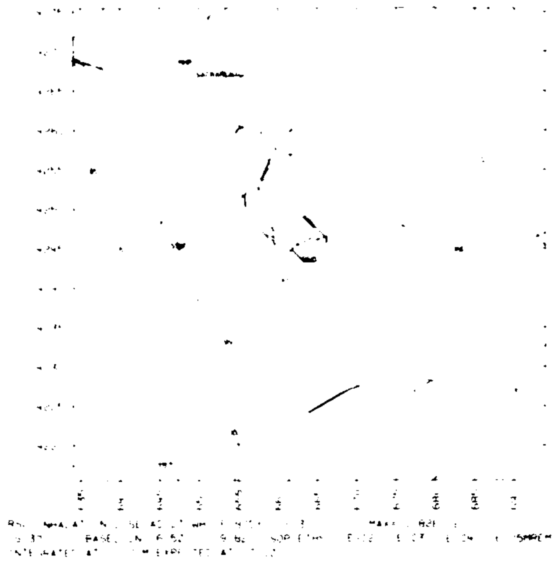

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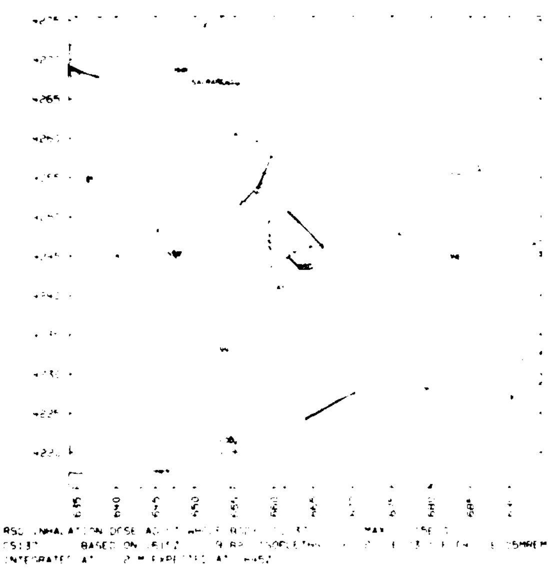

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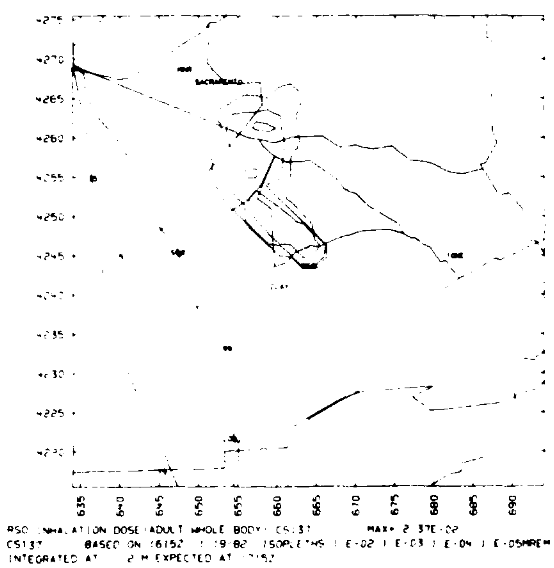

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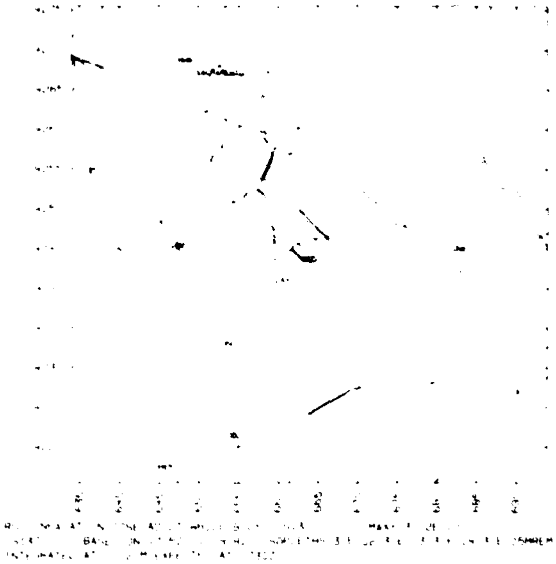

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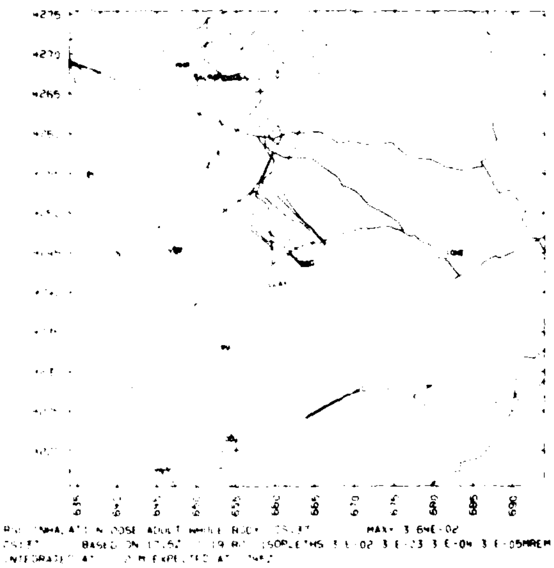

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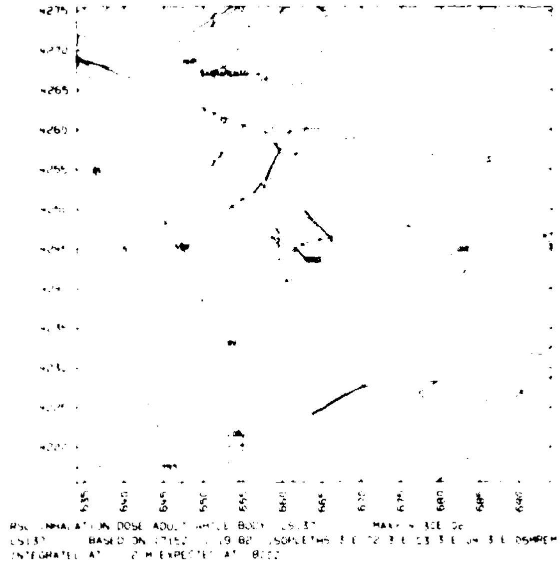

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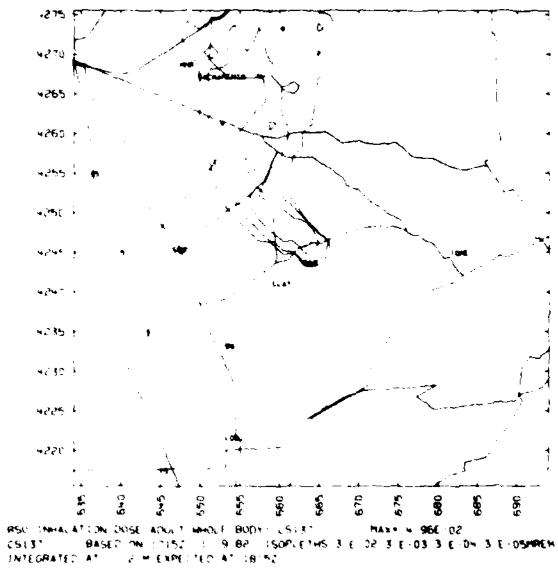

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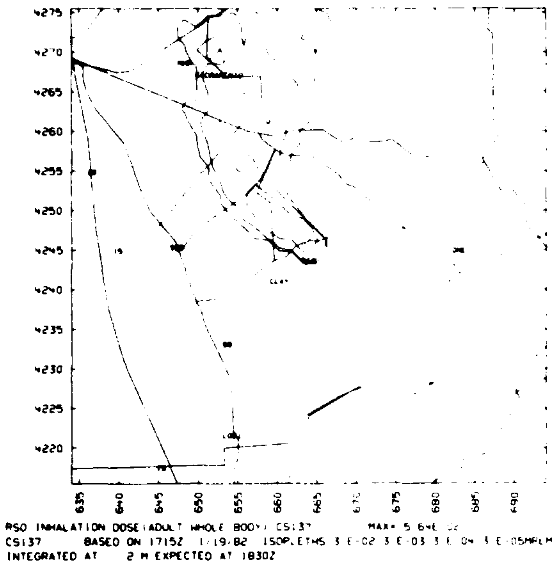

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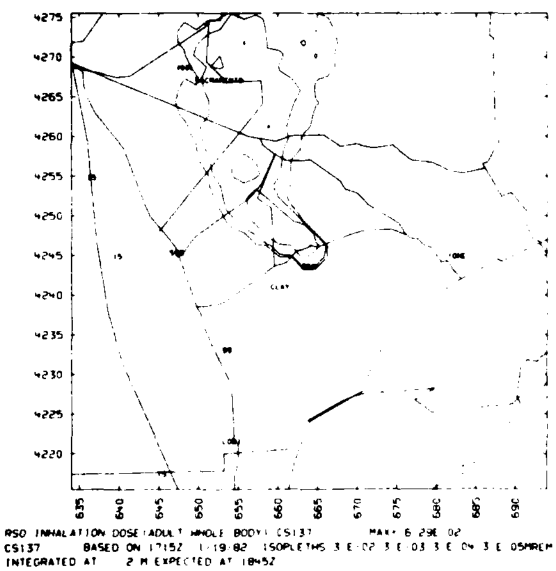

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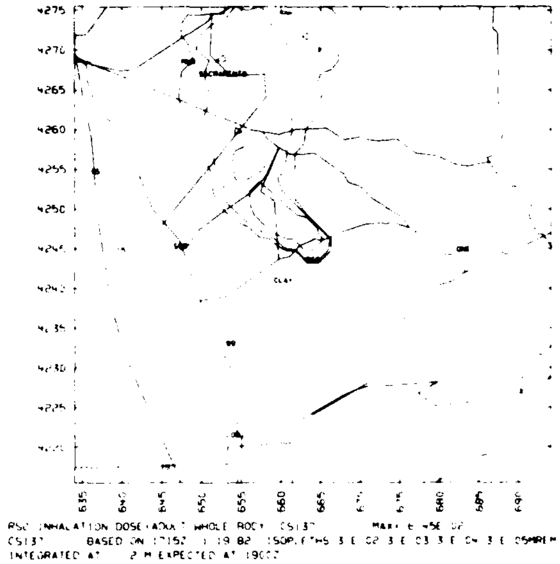

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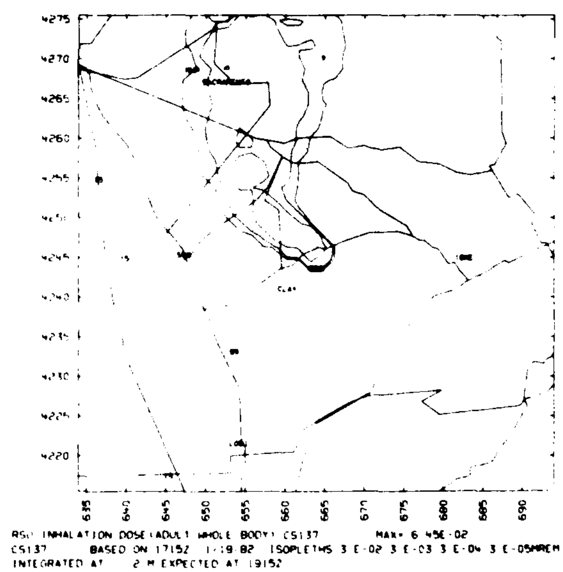

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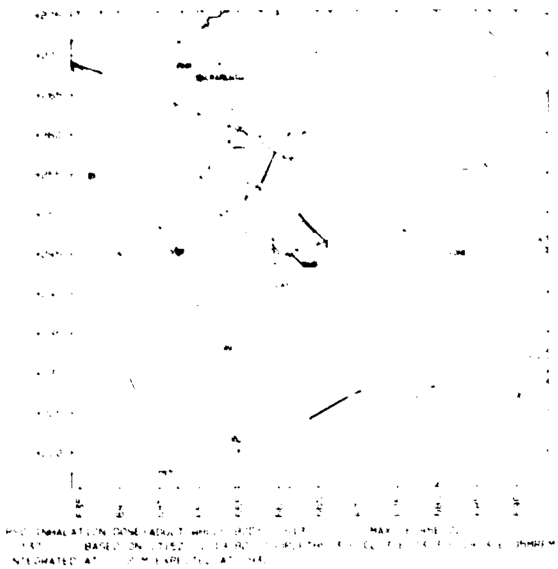

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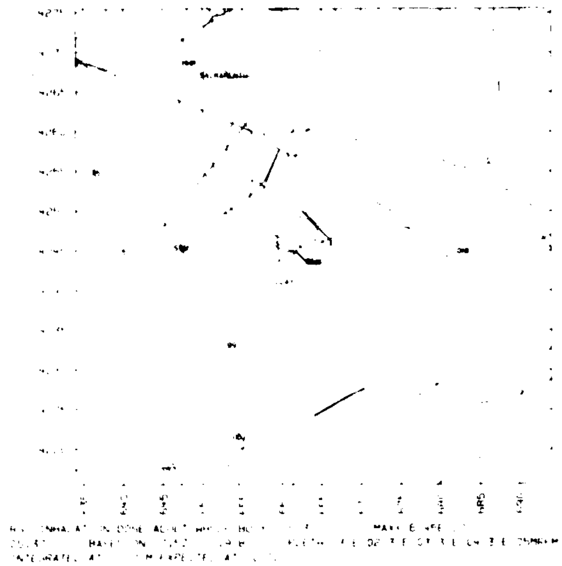

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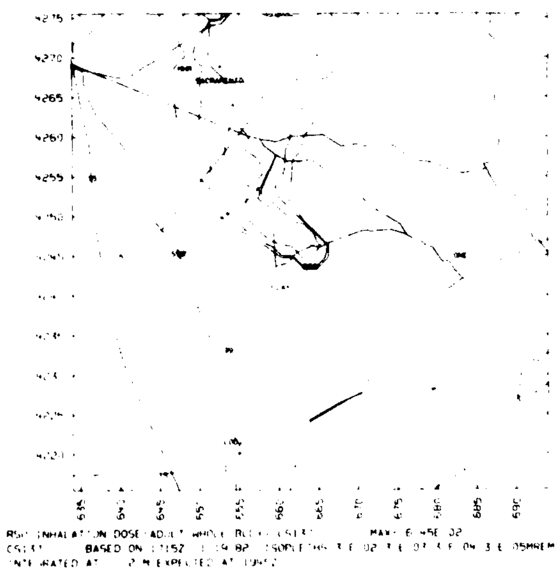

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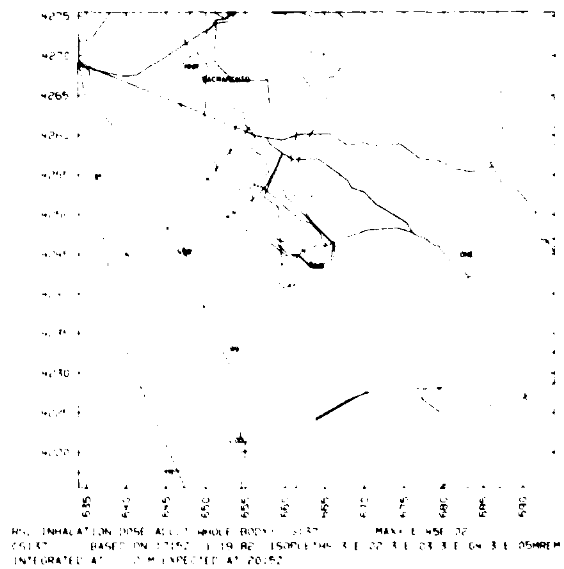

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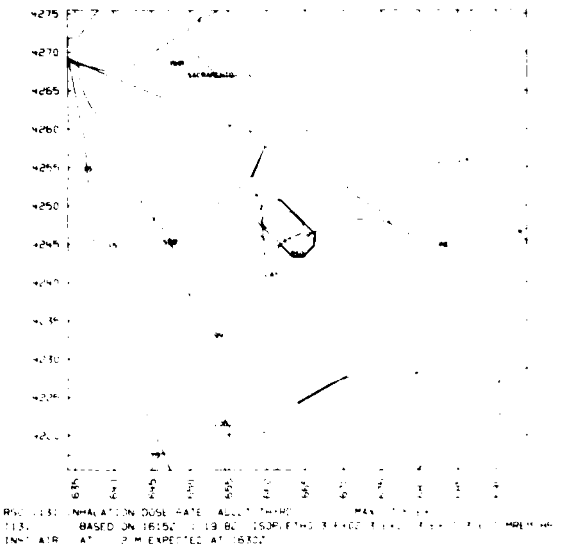

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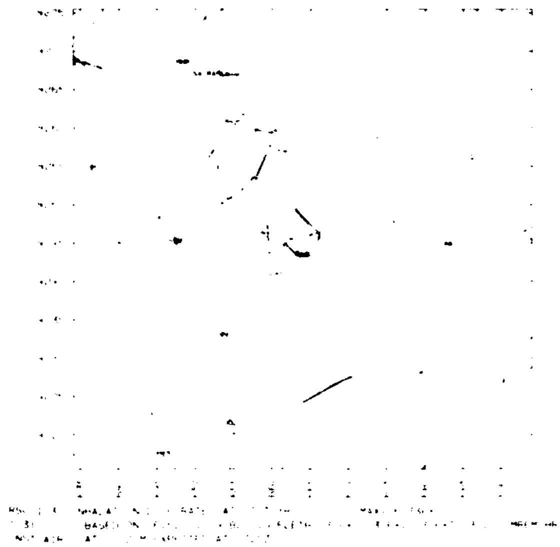

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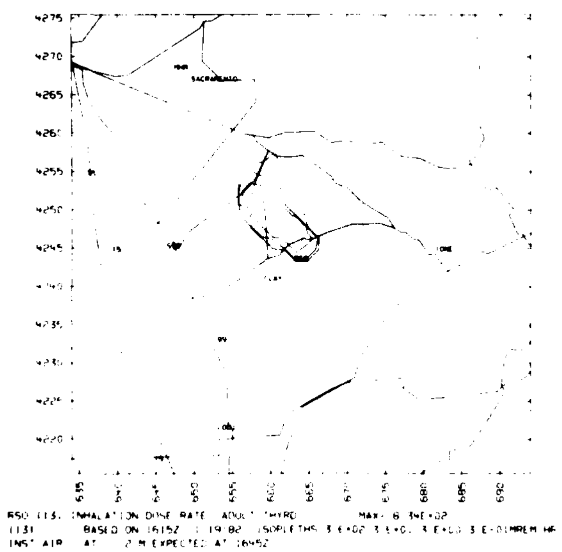

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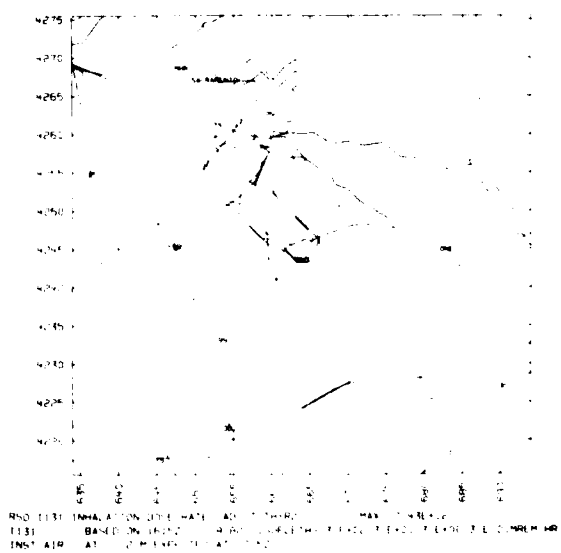

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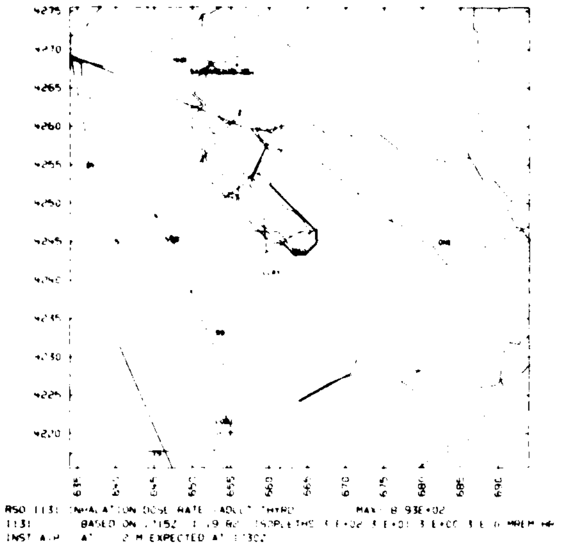

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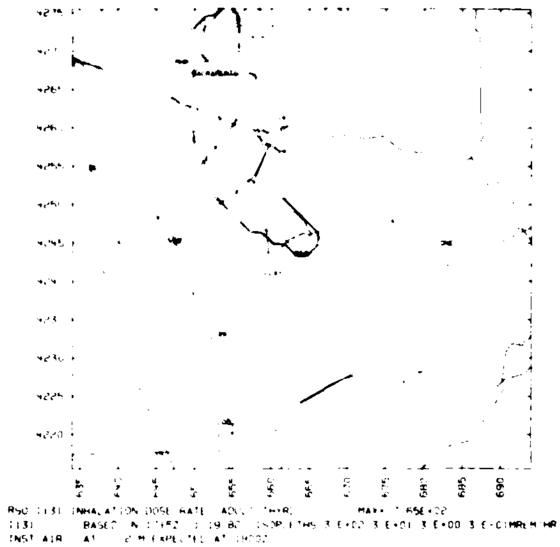

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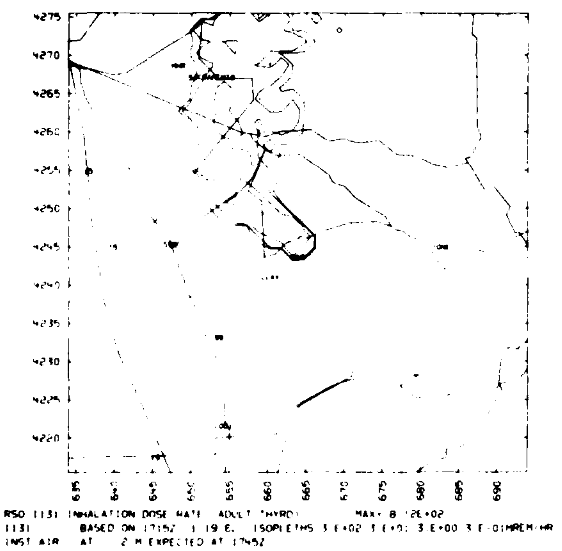

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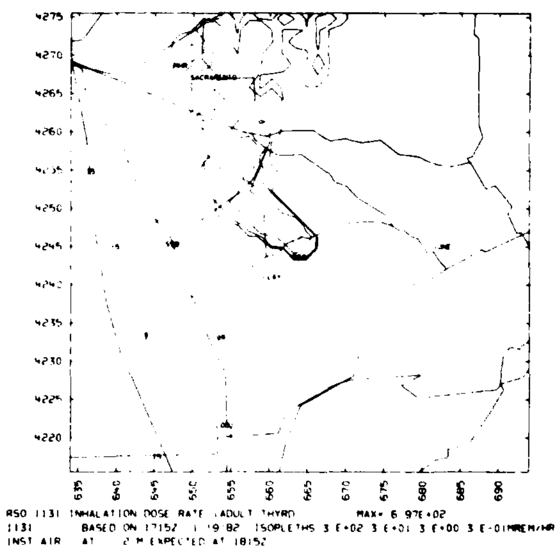

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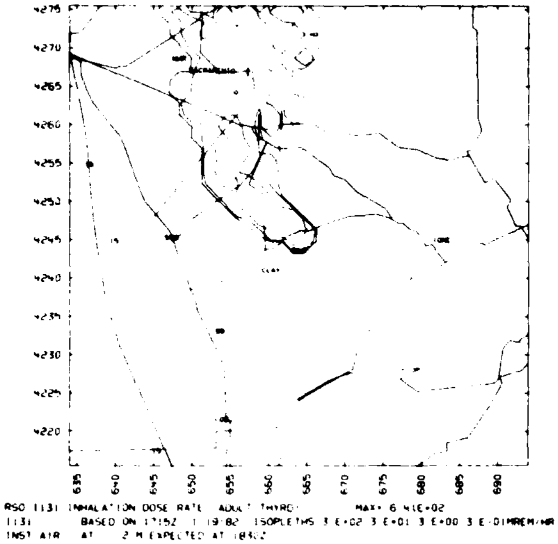

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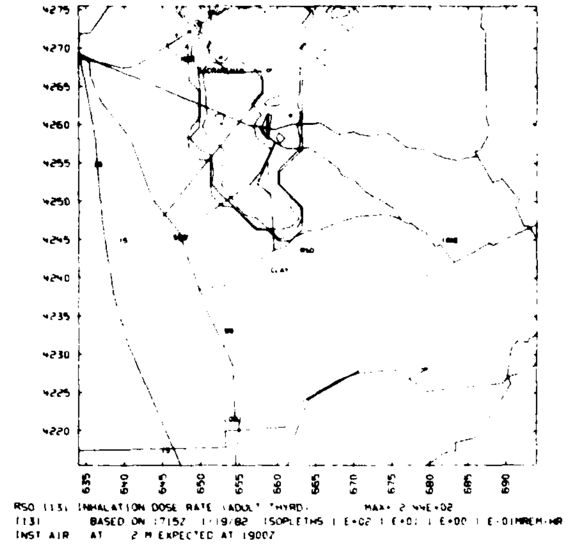

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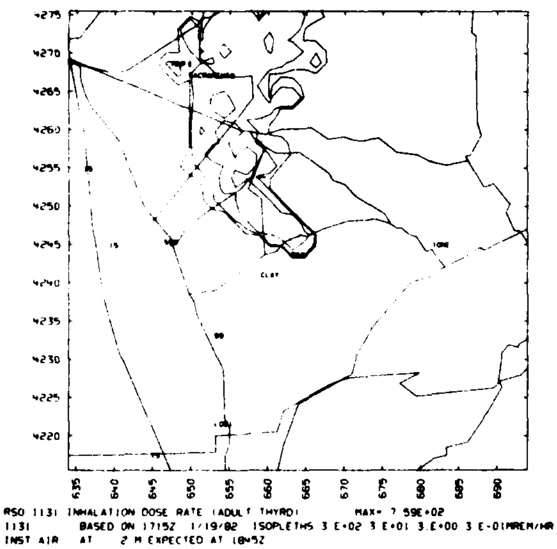

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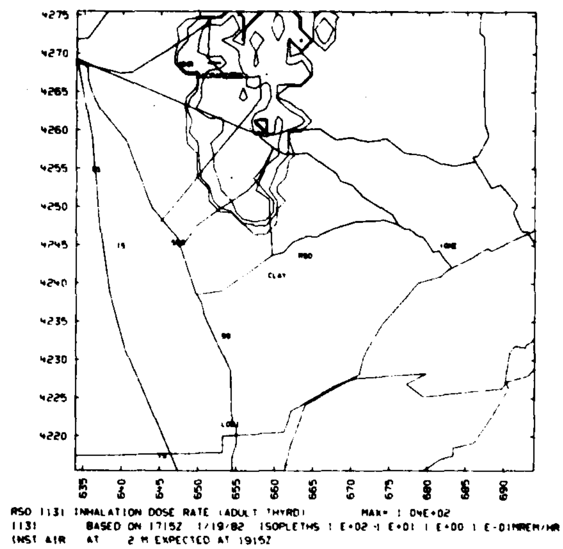

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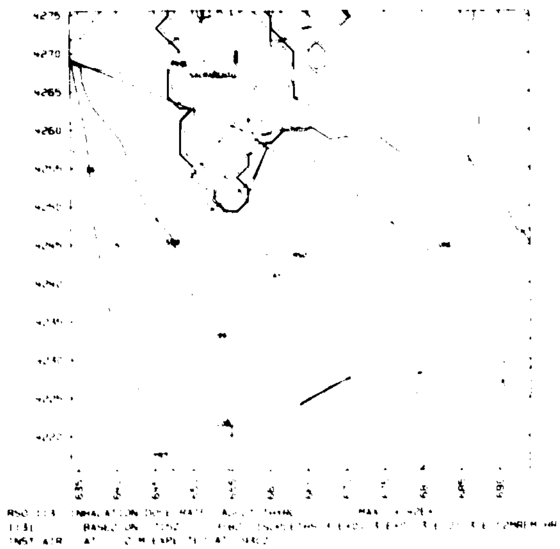

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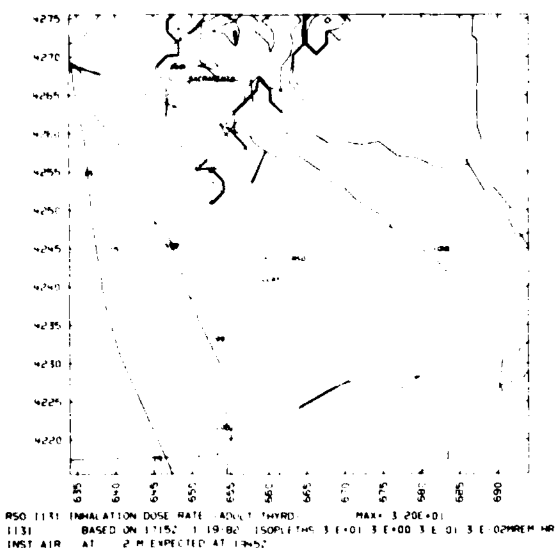

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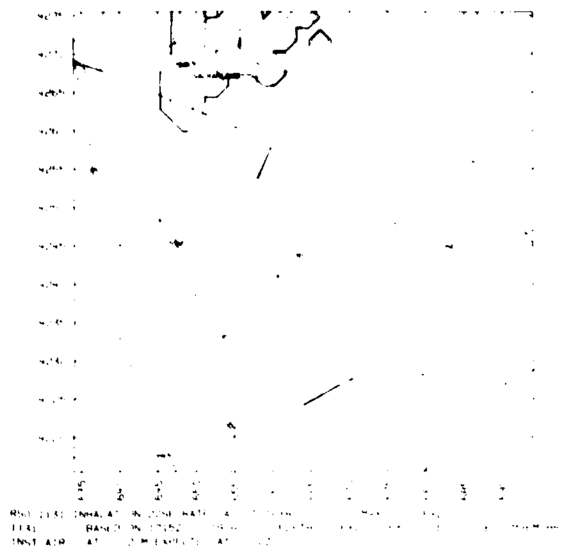

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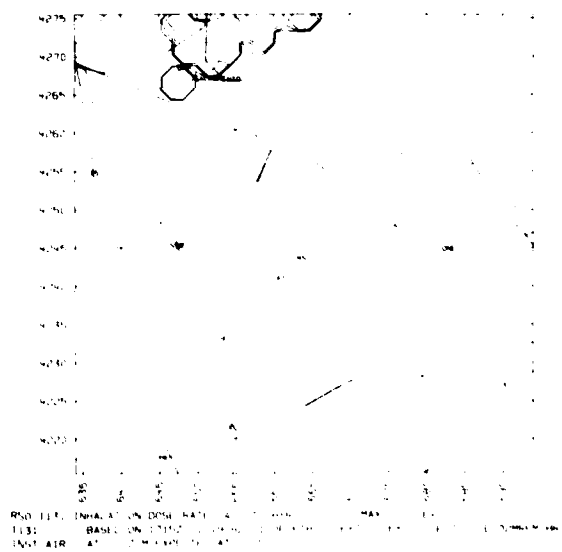

Figure A-48.

Appendix B: Discussion of EVACD Computer Program

Appendix B provides a description of the EVACD computer program that simulates the methodology discussed earlier in "ARAC." The first part of Appendix B describes the main routine called EVACD, which is followed by an alphabetical listing of each subroutine. Some of the subroutines make reference to color graphics displays; these displays are reported in detail in the text in "Sample Case and Outputs." Each common block of the program appears in a separate file; INCLUDE statements were used to incorporate these common blocks in the appropriate routines. The second part of Appendix B describes the input files required by the program. A test case using the sample input files was run; the output is described in the text in "EVACD Methodology."

Description of EVACD Main Routine and Subroutines

Main Routine (EVACD)

EVACD is the main driver routine for the program. It is responsible for calling each subroutine in the correct order. In addition, much of the calculations and reading of data occurs in EVACD. Specifically, data describing the road network of links and nodes, plus initial population placement, are read from the file EVACDB.INP on unit 10. Information describing the specific evacuation case to be run is read from the file EVACDB.CAS on unit 11. This file includes data which describe the evacuation zone—a 15- by 15-mi square-shaped zone divided into 1600 grid squares in a 40 $\times$ 40 arrangement. EVACDB.CAS contains the x- and y-coordinates of the lower left-hand corner of the grid and the x- and y-dimensions of each grid square.

EVACD is arranged in four main sections. The first section, which is executed only once, reads the data from units 10 and 11, calculates the location of each node on the 40 $\times$ 40 grid and the length of each link and calculates the total population to be evacuated. Then in the second section, EVACD enters a time increment loop, which is executed a number of times as specified in the EVACDB.INP input. Within this time loop are calls to the various subroutines that provide the dynamic color graphics display of the evacuation. The dynamic display is not updated at every time step; it is updated only once within a time interval called "dispersion update time," specified in EVACEDB.CAS. Currently the update occurs every 15 min.

The third and fourth sections are a link and a node loop, both of which are nested within the time loop. The link loop performs the dynamic link scan as described in "EVACD Methodology: Dynamic Link Scan." Variables calculated include the population, flow, and queue associated with each link at each time step. The node loop performs the vehicular balance node scan described in "EVACD Methodology: Vehicular Balance Node Scan." Variables calculated include the population entering and leaving each node at each time step.

The time loop is terminated when all of the numbers of specified time steps have been executed, or when a specified fraction of the population has been evacuated beyond a 10-mi radius from the release point. This fraction is also input from EVACDB.CAS. The program ends following termination of the time loop.

Subroutine DATA

At each dispersion update (15 min intervals) DATA is called. This subroutine reads the airborne release meteorological transport and diffusion data supplied by Lawrence Livermore National Laboratory. The data are presented in three separate input files. File I131.LLNL on Unit 15 contains thyroid dose due to inhalation of ^{131}I. File XE133.LLNL on unit 16 contains whole-body doses due to exposure to ^{133}Xe. File CS137.LLNL on unit 17 contains total-body doses due to inhalation of ^{137}Cs. In each case, the doses are given in mrem at each of the 1600 grid squares. The doses change every 15 min until 4.5 h after the release.

Subroutine DISP

DISP is called at the start of the calculation and at each dispersion update. It displays the current link and node numerical data. The size of the population density on each link is reflected by drawing the link

as a thicker line for higher densities. Similarly, dense queues are drawn as thick lines. On the color graphics display, links are drawn in yellow and queues are drawn in orange. The population entering each input and output node is symbolized by four equally spaced concentric circles. The radius of the outer circle reflects the size of the population of the node, with larger radii indicating larger populations. Input nodes are drawn in orange and output nodes are drawn in gold.

Subroutine DSCALC

DSCALC is called at each step following the execution of the link loop. DSCALC calculates the dose from ^{131}I, ^{133}Xe, and ^{137}Cs to the population presently on each link. This is done by comparing the grid boxes, through which a particular link passes, with the doses at the center of each box (input files I131.LLNL, XE133.LLNL, and CS137.LLNL). At each time step the total accumulated doses from the three nuclides are calculated. At each dispersion update these total doses are typed on the color graphics display in the top right corner.

Subroutine ERROR

Some of the information required by the program is provided interactively by the user. If the user makes a mistake, ERROR will type an error message and allow the user to try again.

Subroutine HISTO

HISTO provides a color graphics display of a histogram plot depicting the population in 1-mi rings around the reactor site at each dispersion update. The rings go out to 10 mi, with an eleventh histogram showing the number of people evacuated beyond the 10-mi zone. This plot is useful because it gives an indication of the progress of the evacuation.

Subroutine INITIA

INITIA is called by subroutine SITE. The purpose of this subroutine is to initialize the LLNL GRAFCORE graphics package prior to the plotting of the road network and associated evacuation information. INITIA sets up the reference 15- by 15-mi coordinate system used for the plots.

Subroutine ISOPLT

At each dispersion update, the user can choose to plot dose isopleths for the three nuclides ^{131}I, ^{133}Xe, and ^{137}Cs. The contour levels are supplied by Lawrence Livermore National Laboratory for each nuclide at each 15-min interval and are stored in the data file ACLEVS.DAT on unit 8. These isopleths can selectively appear on the screen with the node and link population data, which makes it possible to determine the parts of the road network that are particularly dangerous as far as exposure is concerned.

Subroutine LNKSET

LNKSET is called once at the beginning of the program. It determines the length of each link, the beginning and end nodes, the grid boxes in the 40×40 grid through which each link passes, and the length of the segment of the link within each grid box. The length and location of the segments of each link are required for the dose calculations.

Subroutine NODSET

NODSET is called once at the beginning of the program. It determines the grid location of each node.

Subroutine PLTEND

PLTEND is called to terminate each plot, both road network plots and histogram plots.

Subroutine PLTSET

PLTSET is called by subroutine ISOPLT. At each dispersion update the user can choose to superimpose current dose isopleths on the plot of the road network. However, only one nuclide can be displayed at a time. PLTSET asks the user for the nuclide of interest, loads the appropriate dose data into a variable U, dimensioned 40×40, loads the appropriate contour levels into a variable ACLEVS, dimensioned 4, and returns these values to ISOPLT to be plotted. PLTSET also types information in the top right corner of the screen, identifying the nuclide of interest and the contour levels plotted.

Subroutine SITE

SITE is called at the start of the calculation and at each dispersion step and plots site-specific features as a prelude to the plotting of isopleths and populations designed by links and nodes. These features include the reactor site boundary, the reactor building, and a lake within the site boundary. SITE also plots the road network and county lines. After SITE plots the links and nodes of the road network, subroutine DISP draws over the links and nodes to indicate population density.

Description of EVACD Input Files

The EVACD program uses six input files (Table B-1) as described in detail below.

Table B-1. EVACD input files.

Unit number	File name	Contents
8	ACLEVS.DAT	Contour levels to be plotted each time step
10	EVACDB.INP	Road network information
11	EVACDB.CAS	Specific evacuation case information
15	I131.LLNL	40 × 40 doses due to ^{131}I each time step
16	XE133.LLNL	40 × 40 doses due to ^{133}Xe each time step
17	CS137.LLNL	40 × 40 doses due to ^{137}Cs each time step

ACLEVS.DAT

This file contains contour levels to be plotted for each nuclide. There are 18 dispersion updates representing 15-min intervals and four contour levels for each nuclide at each update. On each line in the file, the first four numbers are contour levels for ^{131}I inhalation dose, the next four are contour levels for ^{133}Xe direct dose, and the last four are countour levels for ^{137}Cs inhalation dose.

EVACDB.INP

This file contains information regarding the road network, plus problem-specific data. The first line is merely a title describing the specific case. Line 2, read in free format, is as follows:

PPV, VL, T, TPRINT, POPFRC, NOPT1,

where

PPV = average number of people per vehicle,
VL = vehicle length (mi),
T = time increment (h),
TPRINT = length of time between dispersion updates (h),
POPFRC = fraction of population which, if evacuated, would terminate the problem, and
NOPT1 = an option. If *NOPT1* is not equal to 1, the code will not execute subroutines *LNKSET* and *NODSET* and thus will not set up the geometry necessary to calculate population doses. If doses are desired, *NOPT1* should be set to 1.

Line 3, also read in free format, is

NTIMES, NNODES, NLINKS, NPOPN,

where

NTIMES = maximum number of time intervals that the problem will run,
NNODES = number of nodes in the road network,
NLINKS = number of links in the road network, and
NPOPN = number of input nodes, i.e., nodes at which people can enter the road network.

The next "*NNODES*" lines, read in format I5, A1, 2F6.2, are

NODNM(N), NODID(N), XNODE(N), YNODE(N), N = 1,NNODES,

where

NODNM = the node ID number,
NODID = the node type ID, with "A" denoting an input node, "Z" denoting an output node, and "B" denoting all other nodes,
XNODE = the x-position of the node, and
YNODE = the y-position of the node.

The next "*NPOPN*" lines, read in free format, are

ID, POPIN(ID), CAPNOD(ID), PIN(ID),

where

ID = the ID number of the input node and is equivalent to *NODNM* above,
POPIN = the initial number of people at the input node,
CAPNOD = the capacity of the input node, i.e., the number of vehicles/h that can enter the input node, and
PIN = preference factor (fraction from 0–1) for the input node.

The last "*NLINKS*" lines, read in free format, are

LID(L), LLD(L), LNUML(L), FFS(L), CAP(L), AL(L), AR(L), PFIN(L), GSIN(L), LNIN(L), LNOUT(L), QINIT(L), VEHINI(L), L=1, NLINKS,

where

LID = the link ID number,
LLD = the length of the link (mi),
LNUML = the number of traffic lanes for the link,
FFS = the free flow speed of the link (mi/h),
CAP = the capacity of the link (vehicles/h); this is the maximum number of vehicles that have a reasonable expectation of passing over a given section of roadway in 1 h,
AL = the left turn adjustment factor for the link (currently not in use),
AR = the right turn adjustment factor for the link (currently not in use),
PFIN = the preference factor (fraction from 0 - 1) for the link into its output node, i.e., the fraction of the time that traffic from the link can pass through the output node, relative to other links with the same output node,
GSIN = the green split, or fraction of the time that traffic signals on the link are green; if a negative number is used the program will use the green-split variable,
LNIN = the ID number of the input node for the link,
LNOUT = the ID number of the output node for the link,
QUNIT = the number of vehicles initially in a queue at the end of the link, and
VEHINI = the initial number of vehicles on the link.

EVACDB.CAS

This file contains information regarding specific parameters for the evacuation case being run. The first line is merely a title describing the case. Line 2, read in free format, is as follows:

TNOTIC, TDELAY, TUPD,

where

TNOTIC = the notification time, or the time that elapses following the release until people are notified to evacuate (h),
TDELAY = the time that elapses following notification before people begin to evacuate (h), and
TUPD = the time between dispersion updates (h).

Line 3, read in free format, is

XZERO, YZERO, NRINGS, NZONES,

where

XZERO = the x-position of the release point,
YZERO = the y-position of the release point,
NRINGS = the number of "rings" around the release point, established for the purpose of watching the progress of the evacuation; in the sample input, ten 1-mi rings were used, with an eleventh ring from 10 mi out to 15 mi for the evacuated population, and
NZONES = the number of evacuation zones under consideration.

Line 4, read in free format, is

RING(N), N = 1, NRINGS,

where

RING(N) = the outer radius of the *n*th ring (mi).

Following line 4, the file contains "*NZONES*" pairs of lines, as follows:

ZONE(J), NSEC(J)
MSECS(J,I), I = 1,NSEC(J),

where

ZONE(J) = the outer radius of the *j*th evacuation zone (mi),
NSEC(J) = the number of sectors included in the *j*th evacuation zone, and
MSECS(J,I) = the ID numbers of the sectors included in the *j*th evacuation zone.

Usually the area around the release point will be divided into 16 equal sectors numbered 1 through 16. It is possible to set up an evacuation area in a shape other than a circle by having an outer evacuation zone consist of different sectors from an inner zone. For example, a key shaped area can be established by having an inner zone out to 5 mi consist of all 16 sectors and have an outer zone out to 10 mi consist of about 3 sectors. The sample problem uses only one zone.

The last line of the file, read in free format, is

NGRIDX, NGRIDY, XCORN, YCORN, DELX, DELY,

where

$NGRIDX$ = the number of grid boxes in the x-direction for which dose information is given,
$NGRIDY$ = the number of grid boxes in the y-direction for which dose information is given,
$XCORN$ = the x-position of the lower left corner of the grid (mi from the center),
$YCORN$ = the y-position of the lower left corner of grid (mi from the center),
$DELX$ = the length of a grid box in the x-direction (mi), and
$DELY$ = the length of a grid box in the y-direction (mi).

I131.LLNL, XE133.LLNL, CS137.LLNL

These three files contain the dose information for the nuclides ^{131}I, ^{133}Xe, and ^{137}Cs, respectively. They are set up on the basis of a 41 × 41 grid, with 41 × 41 values at each of 18 times. The EVACD program uses a 40 × 40 grid, so it ignores data corresponding to the 41st row and 41st column. The order of the data is as follows:

$$\left.\begin{array}{ll} J=1, & I=1+41 \\ J=2, & I=1+41 \\ & \cdot \\ & \cdot \\ & \cdot \\ J=41, & I=1+41 \end{array}\right\} \text{Time since release} = 0.25\text{ h} \quad ,$$

$$\left.\begin{array}{ll} J=1, & I=1+41 \\ J=2, & I=1+41 \\ & \cdot \\ & \cdot \\ & \cdot \\ J=41, & I=1+41 \end{array}\right\} \text{Time since release} = 0.50\text{ h} \quad ,$$

$$\begin{array}{ll} & \cdot \\ & \cdot \\ & \cdot \end{array}$$

$$\left.\begin{array}{ll} J=1, & I=1+41 \\ J=2, & I=1+41 \\ & \cdot \\ & \cdot \\ & \cdot \\ J=41, & I=1+41, \end{array}\right\} \text{Time since release} = 4.50\text{ h} \quad ,$$

where J refers to the y-coordinate of a data point and I refers to the x-coordinate of a data point. Data are read in 12E10.2 format.

Appendix C:
Listing of EVACD Main Routine, Subroutines, and Common Files

```
      PROGRAM EVACDB
C REAL-TIME EVACUATION MODEL
C FEBRUARY 1981
C
C
      INCLUDE 'DSKD:PARAM.COM'
      INCLUDE 'DSKD:NODE.COM'
      INCLUDE 'DSKD:LINK.COM'
      INCLUDE 'DSKD:DOSE.COM'
      INCLUDE 'DSKD:ROAD.COM'
      include 'dskd:text.com'
      DIMENSION TITLE(20),ETITLE(20)
      DIMENSION NODNM(N1),POPIN(N1),CAPNOD(N1),
     *          PIN(N1),NLFN(N1),NLFO(N1),VEHIN(N1),VEH(N1),
     *          VEHND(N1),W(N1),PF(N1),NODOUT(N1),EXIT(N1)
      DIMENSION LID(N2),LLD(N2),FFS(N2),DJAM(N2),
     *          PFIN(N2),GSIN(N2),QINIT(N2),
     *          VEHIN1(N2),VEHICS(N2),QUEOUT(N2),QUELEN(N2),
     *          MINP(N2),DENS(N2),SPEED(N2),FLOW(N2),VEHTN(N2),
     *          VLEFT(N2),EXVEH(N2),CS(N2),CAPLNK(N2),CAP(N2),
     *          AL(N2),AR(N2),APPCAP(N2),VI(N2),P(N2),PT(N2),
     *          VO(N2),MOUT(N2),VW(N2),PI(N2)
      DIMENSION LINKIN(N1,N3),LINKOT(N1,N3)
      REAL LLD,LENGTH,NODOUT,MINP,MOUT
      DATA A,Z/'A   ','Z   '/
      NVARL=12*N2+3*N1+2
      open ( unit=8, status='old', file='dsk:aclevs.dat' )
      OPEN(UNIT=10,status='old',file='dsk:EVACDB.INP')
      OPEN(UNIT=11,status='old',file='dsk:EVACDB.CAS')
      OPEN(UNIT=12,status='new',file='dsk:EVACDB.OUT')
      OPEN(UNIT=15,status='old',file='dsk:i131.LLL')
      OPEN(UNIT=16,status='old',file='dsk:xe133.LLL')
      OPEN(UNIT=17,status='old',file='dsk:cs137.LLL')
c     TYPE 3000
3000  FORMAT(1H1,'  BEGIN EVACD EVACUATION PROGRAM',
     *       // ' APPROPRIATE FILES ARE BEING READ IN')
      READ(10,1106)TITLE
1106  FORMAT(20A4)
      READ(10,*)PPV,VL,T,TPRINT,POPFRC,NOPT1
      READ(10,*)NTIMES,NNODES,NLINKS,NPOPN
      READ(10,1105)(NODNM(N),NODID(N),XNODE(N),YNODE(N),N=1,NNODES)
c     TYPE 1500,TITLE
      WRITE(12,1600)TITLE
1600  FORMAT(20A4)
1500  FORMAT(1H1,10X,20A4)
      WRITE(12,1601)PPV,VL,T,NTIMES,TPRINT,NNODES,NLINKS,POPFRC,NOPT1
1601  FORMAT(3E10.2,I6,E10.2,2I6,E10.2,I6)
c     TYPE 1501,PPV,VL,T,NTIMES,TPRINT,NNODES,NLINKS,POPFRC,NOPT1
1501  FORMAT(//2X,'INPUT PARAMETERS',
     *          //5X,'PEOPLE PER VEHICLE           =',3X,F10.1,
     *           /5X,'VEHICLE LENGTH(MI)           =',3X,1PE10.2,
     *           /5X,'TIME INCREMENT(HR)           =',3X,0PF10.3,
     *           /5X,'NUMBER OF TIME INCREMENTS    =',7X,I6,
     *           /5X,'REPORTING TIME(HR)           =',3X,F10.3,
     *           /5X,'NUMBER OF NODES              =',7X,I6,
     *           /5X,'NUMBER OF LINKS              =',7X,I6,
     *           /5X,'CUTOFF FRACTION              =',3X,F10.4
     *           /5X,'NOPT1                        =',7X,I6)
1105  FORMAT(I5,A1,2F6.2)
      DO 1 N=1,NPOPN
      READ(10,*)ID,POPIN(ID),CAPNOD(ID),PIN(ID)
C TOTAL UP ALL POPULATION ENTERING 'A' NODES
      TTPOPN=TTPOPN+POPIN(ID)
```

Figure C-1. EVACD main routine.

```
1       CONTINUE
        READ(10,*)(LID(L),LLD(L),LNUML(L),FFS(L),CAP(L),AL(L),AR(L),
     *             PFIN(L),GSIN(L),LNIN(L),LNOUT(L),QINIT(L),

     *             VEHINI(L),L=1,NLINKS)
C READ IN EVACUATION-SPECIFIC DATA
        READ(11,1106)ETITLE
        READ(11,*)TNOTIC,TDELAY,TUPD
        READ(11,*)XZERO,YZERO,NRINGS,NZONES
        READ(11,*)(RING(N),N=1,NRINGS)
c       TYPE 3001
3001    FORMAT(1H1,'  SPECIFIC EVACUATION CASE IS:')
        TYPE 2999,ETITLE
2999    FORMAT(/1X,40A4)
c       TYPE 3002
3002    FORMAT(//5X,'SPECIFIC PARAMETERS FOLLOW:')
c       TYPE 3003,TNOTIC,TDELAY,TUPD
3003    FORMAT(/10X,'NOTIFICATION TIME(HR) =',F6.2,
     *         /10X,'PREPARATION TIME(HR) = ',F6.2,
     *         /10X,'DISPERSION UPDATE(HR)= ',F6.2)
c       TYPE 3004,NZONES
3004    FORMAT(/10X,'NUMBER OF EVACUATION ZONES =',I2)
        DO 200 J=1,NZONES
        READ(11,*)ZONE(J),NSEC(J)
        NS=NSEC(J)
        READ(11,*)(MSECS(J,I),I=1,NS)
c       TYPE 3005,J,ZONE(J),(MSECS(J,I),I=1,NS)
3005    FORMAT(//10X,'ZONE NUMBER',I2,' IS OUT TO',F5.1,' MILES',
     *         /10X,'INCLUDING SECTORS:',
     *         /10X,16I3)
200     CONTINUE
        READ(11,*)NGRIDX,NGRIDY,XCORN,YCORN,DELX,DELY
        IF(NOPT1 .NE. 1)GOTO 85
C CALL NODSET TO SET UP NODE LOCATION(RELATIVE)
        CALL NODSET
C IF ERROR DETECTED GOTO END
        IF(NERROR .EQ. 1)GOTO 171
C CALL LNKSET TO SET UP LINK LENGTH AND LOCATION DATA
        CALL LNKSET
85      CONTINUE
C TOTAL UP ALL POPULATION TO BE EVACUATED
        DO 201 N=1,NNODES
        IF(NODID(N) .NE. 'A   ')GOTO 201
        IF(NODVAC(N) .NE. 1 .AND. NOPT1 .EQ. 1)GOTO 201
        TPOPN=TPOPN+POPIN(N)
201     CONTINUE
        IF(TPOPN .NE. 0.)GOTO 172
        TYPE 2000
2000    FORMAT('  PROGRAM TERMINATED FOR ZERO POPULATION EVACUATION')
        GOTO 171
172     CONTINUE
C       CALL CAPACY
C SET UP NODE AND LINK INFO
        DO 120 L=1,NLINKS
C CALCULATE JAM DENSITY
        DJAM(L)=4.*CAP(L)/FFS(L)
C TOTAL UP ALL POPULATION ON LINKS
        TPOPL=TPOPL+VEHINI(L)*PPV
        NOUT=LNIN(L)
        NIN=LNOUT(L)
        NLFN(NIN)=NLFN(NIN)+1
        NLFO(NOUT)=NLFO(NOUT)+1
        L1=NLFN(NIN)
        L2=NLFO(NOUT)
        LINKIN(NIN,L1)=LID(L)
        LINKOT(NOUT,L2)=LID(L)
120     CONTINUE
1100    FORMAT(2X,I5,4X,A1)
1101    FORMAT(5X,'IN  = ',5I5)
1102    FORMAT(5X,'OUT = ',5I5)
```

Figure C-1. (Continued.)

```
C       CALL LNKPLT
C TOTAL UP POPULATION INITIALLY AT 'A' NODES AND ON ALL LINKS
        TOTPOP=TPOPL+TPOPN
c       TYPE 1604,TOTPOP,TPOPN,TOTPL
1604    FORMAT(//'   TOTAL POPULATION FOR EVACUATION =',F10.0,
     *          /'   TOTAL POPULATION AT NODES       =',F10.0,
     *          /'   TOTAL POPULATION ON LINKS       =',F10.0)
C CALCULATE INITIAL NUMBER OF VEHICLES WAITING TO ENTER INPUT NODE
        DO 5 N=1,NNODES
        VEHIN(N)=POPIN(N)/PPV
C       WRITE(12,1103)N,VEHIN(N),POPIN(N)
5       CONTINUE
1103    FORMAT(1X,'FOR NODE',I5,' INITIAL VEHICLES = ',F6.0,
     *          ' INITIAL POPULATION = ',F6.0)
C TOTAL TIME DELAY BEFORE EVACUATION START IS TNOTIC+TDELAY
        TOTDE=TNOTIC+TDELAY
c       TYPE 3006
3006    FORMAT('  BEGIN RELEASE EVENT AT TIME = 0')
        TMDATA=0.
        TIME=0
C START TIME INCREMENT LOOP
        ndone=0
        TNEXT=TUPD
        DO 10 NT=1,NTIMES
        ndoser=0
        NTM=NT
        IF(TMDATA .LT. -.001 .OR. TMDATA  .GT. .001)GOTO 71
        ndoser=1
        NTMIN=NT-1
        TYPE 3007,TIME
3007    FORMAT(1H0,5X,'TIME SINCE RELEASE(HR) =',F6.2)
        ISITRD=NT-1
75      CALL SITE(ISITRD,TIME)
        IF(NT .EQ. 1)GOTO 72
        CALL DISP(NTM,VL)
        CALL ISOPLT(TNEXT)
        CALL PLTEND
73      TYPE 9000
9000    FORMAT(/' DO YOU WANT TO SEE ISOPLETHS FOR ANOTHER NUCLIDE'
     1  ,' AT THIS TIME STEP?'/' ENTER "Y" FOR YES OR "N" FOR NO.')
        ACCEPT 9001,IANS
9001    FORMAT(A1)
        irtn = str$upcase(%descr(ians),%descr(ians))
        IF(IANS.EQ.'Y') GOTO 75
        IF(IANS.EQ.'N') GOTO 74
        CALL ERROR
        GOTO 73
74      CALL HISTO(RINPOP,time)
        tnext=tnext+tupd
72      CONTINUE
        CALL PLTEND
        IF(NDONE.EQ.1) GO TO 11
        CALL DATA
        TMDATA=-TUPD
71      CONTINUE
        TMDATA=TMDATA+T
C CHECK TO SEE IF EVACUATION HAS STARTED
        TIME=FLOAT(NT)*T
C       TYPE *,TIME
        IF(TIME .GE. TOTDE)NTGO=NTGO+1
        TOTEX=0.
C START LINK LOOP
        DO 20 L=1,NLINKS
        IF(NT .NE. 1)GOTO 21
C SET UP INITIAL LINK OUT QUE
        VEHICS(L)=VEHINI(L)

        QUEOUT(L)=QINIT(L)
        GOTO 19
C CALCULATE LENGTH OF OUT QUE
21      CONTINUE
        VEHICS(L)=VLEFT(L)+MINP(L)
```

Figure C-1. (Continued.)

```
19      QUELEN(L)=QUEOUT(L)*VL/LNUML(L)
c       TYPE 1203,NT,L,VEHICS(L)
        LENGTH=LLD(L)-QUELEN(L)
        IF(LENGTH .GT. 0)GOTO 22
        LENGTH=0.
        DENS(L)=0.
        GOTO 23
22      CONTINUE
C CALCULATE DENSITY(PER LANE)
        DENS(L)=VEHICS(L)/LENGTH/LNUML(L)
23      CONTINUE
C CALCULATE FLOW SPEED
        SPEED(L)=FFS(L)*(1.-DENS(L)/DJAM(L))
C CALCULATE LINK FLOW
        FLOW(L)=DENS(L)*SPEED(L)*LNUML(L)
C CALCULATE VEHICLES REACHING END OF LINK OR OUT QUE
        VEHTN(L)=FLOW(L)*T
        IF(VEHTN(L) .GE. VEHICS(L))VEHTN(L)=VEHICS(L)
C VEHICLES REMAINING ON LINK
        VLEFT(L)=VEHICS(L)-VEHTN(L)
        XL(L,1)=VEHICS(L)
        XL(L,2)=QUEOUT(L)
        XL(L,3)=LENGTH
        XL(L,4)=DENS(L)
        XL(L,5)=SPEED(L)
        XL(L,6)=FLOW(L)
        XL(L,7)=VEHTN(L)
        XL(L,8)=VLEFT(L)
        QUEOUT(L)=QUEOUT(L)+VEHTN(L)
        QUELEN(L)=QUEOUT(L)*VL/LNUML(L)
        LENGTH=LLD(L)-QUELEN(L)
        XL(L,9)=QUEOUT(L)
        XL(L,10)=LENGTH
        IF(LENGTH .LE. 0)LENGTH=0.
        DENS(L)=VLEFT(L)/LENGTH/LNUML(L)
        EXVEH(L)=LENGTH*(DJAM(L)-DENS(L))*LNUML(L)
        IF(EXVEH(L) .LE. 0.)EXVEH(L)=0.
C       WRITE(12,1104)NT,L,VEHICS(L),QUELEN(L),DENS(L),SPEED(L),FLOW(L),
C     *                   VEHTN(L),VLEFT(L),EXVEH(L)
1104    FORMAT(1X,2I5,8F7.0)
20      CONTINUE
C***** END OF LINK LOOP
        zzin=0.         !pop entering
        zzout=0.        !pop leaving
        zzleft=0.       !pop on links
        zzque=0.        !queue on links
        do 8070 l=1,nlinks
        zzque=zzque+xl(l,9)
8070    zzleft=zzleft+xl(l,8)
        do 8071 n=1,nnodes
        zzin=zzin+xn(n,2)
8071    zzout=zzout+xn(n,3)
        zztot=zzleft+zzque+zzin+zzout
        call dscalc(ntm,t,tupd,ndoser,ppv)
C START NODE LOOP
        DO 30 N=1,NNODES
C CHECK FOR IN OR OUT NODE
        NODT=0
        IF(NODID(N) .NE. 'A   ')GOTO 31
        IF(NODVAC(N) .NE. 1 .AND. NOPT1 .EQ. 1)GOTO 31
        NODT=1
C SET UP INPUT INTO NODE
        IF(NTCO .EQ. 1)VEH(N)=VEHIN(N)
C MAXIMUM INPUT IN VEHICLES PER TIME INTERVAL
        VEHND(N)=CAPNOD(N)*T
        IF(VEH(N) .LE. VEHND(N))VEHND(N)=VEH(N)
C       TYPE 1200,NT,N,CAPNOD(N),VEH(N),VEHND(N)
1200    FORMAT(1X,2I5,3F7.0)
31      CONTINUE
        XN(N,1)=VEH(N)
C       TYPE 1201,NT,N,NODID(N)
1201    FORMAT(1X,2I5,5X,A1)
        IF(NODID(N) .EQ. 'Z   ')NODT=2
```

Figure C-1. (Continued.)

```
C SET UP NUMBER OF INPUT AND OUTPUT LINKS FOR NODE
      NLI=NLFN(N)
      NLO=NLFO(N)
      W(N)=0.
C LOOP OVER INPUT LINKS
      IF(NLI .EQ. 0)GOTO 46
      DO 32 L=1,NLI
C LINK IS INPUT LINK L TO NODE N
      LINK=LINKIN(N,L)
      VW(LINK)=QUEOUT(LINK)
      W(N)=W(N)+VW(LINK)/LNUML(LINK)
32    CONTINUE
C ADD POTENTIAL INPUT VEHICLES FROM INPUT NODE(TYPE A)
      IF(NODT .EQ. 1)W(N)=W(N)+VEHND(N)
      IF(W(N) .LE. 0.)W(N)=1.
C CALCULATE GREEN SPLIT
      DO 33 L=1,NLI
      LINK=LINKIN(N,L)
      IF(GSIN(LINK) .GE. 0.)GOTO 34
      GS(LINK)=VW(LINK)/LNUML(LINK)/W(N)
      GOTO 35
34    GS(LINK)=GSIN(LINK)
35    CONTINUE
C CALCULATE ENTRY INPUT GREEN SPLIT
      CAPLNK(LINK)=CAP(LINK)*AL(LINK)*AR(LINK)
C USE FIRST CONSTRAINT
      APPCAP(LINK)=CAPLNK(LINK)*GS(LINK)
      VI(LINK)=APPCAP(LINK)*T
      IF(VI(LINK) .GE. VW(LINK))VI(LINK)=VW(LINK)
33    CONTINUE
      IF(NODT .EQ. 1)ENTGS=VEHND(N)/W(N)
      GOTO 47
46    CONTINUE
      IF(NODT .EQ. 1)ENTGS=1.
47    CONTINUE
C CALCULATE OUTBOUND LINK PREFERENCES
      PF(N)=0.
      IF(NODT .EQ. 2)GOTO 41
      DO 36 L=1,NLO
      LINK=LINKOT(N,L)
      PF(N)=PF(N)+PFIN(LINK)*SPEED(LINK)
36    CONTINUE
      IF(PF(N) .LE. 0.)PF(N)=1.
      DO 37 L=1,NLO
      LINK=LINKOT(N,L)
      P(LINK)=PFIN(LINK)*SPEED(LINK)/PF(N)
37    CONTINUE
      DO 38 L1=1,NLO
      LINK1=LINKOT(N,L1)
      PT(LINK1)=0.
      IF(NLI .EQ. 0)GOTO 48
      DO 39 L2=1,NLI
      LINK2=LINKIN(N,L2)
      PI(LINK2)=1.
      PT(LINK1)=PT(LINK1)+VI(LINK2)*P(LINK1)*PI(LINK2)
39    CONTINUE
      IF(NODT .EQ. 1)PT(LINK1)=PT(LINK1)+VEHND(N)*P(LINK1)*PIN(N)
      GOTO 49
48    CONTINUE
      IF(NODT .EQ. 1)PT(LINK1)=VEHND(N)
49    CONTINUE
C CALCULATE OUTBOUND LINK1 VOLUME RECEIVED(SECOND CONSTRAINT)
      VO(LINK1)=CAP(LINK1)*T
      IF(PT(LINK1) .LE. VO(LINK1))VO(LINK1)=PT(LINK1)
      IF(EXVEH(LINK1) .LE. VO(LINK1))VO(LINK1)=EXVEH(LINK1)
      MINP(LINK1)=0.
      IF(PT(LINK1) .LE. 0.)PT(LINK1)=1.
      IF(NLI .EQ. 0)GOTO 42
      DO 40 L2=1,NLI
      LINK2=LINKIN(N,L2)
      PI(LINK2)=1.
      MOUT(LINK2)=VI(LINK2)*P(LINK1)*PI(LINK2)*VO(LINK1)/PT(LINK1)
```

Figure C-1. (Continued.)

```
      MINP(LINK1)=MINP(LINK1)+MOUT(LINK2)
43    CONTINUE
      QUEOUT(LINK2)=QUEOUT(LINK2)-MOUT(LINK2)
      IF(QUEOUT(LINK2) .LE. 0.)QUEOUT(LINK2)=0.
      XL(LINK2,11)=MOUT(LINK2)
      XL(LINK2,12)=QUEOUT(LINK2)
40    CONTINUE
42    CONTINUE
      IF(NOUT .NE. 1)GOTO 44
      NODOUT(N)=VEHND(N)*P(LINK1)*PIN(N)*VO(LINK1)/PT(LINK1)
      MINP(LINK1)=MINP(LINK1)-NODOUT(N)
      VEH(N)=VEH(N)-NODOUT(N)
      IF(VEH(N) .LE. 0.)VEH(N)=0.
44    CONTINUE
C     TYPE 1202,NT,N,LINK1,MINP(LINK1),NODOUT(N),VEH(N)
1202  FORMAT(10X,3I5,3F7.0)
38    CONTINUE
      GOTO 52
41    CONTINUE
      DO 45 L=1,NLI
      LINK=LINKIN(N,L)
      EXIT(N)=EXIT(N)+VI(LINK)
C     TYPE 1203,NT,N,EXIT(N)
1203  FORMAT(10X,2I5,F7.1)
      MOUT(LINK)=VI(LINK)
      QUEOUT(LINK)=QUEOUT(LINK)-MOUT(LINK)
      XL(LINK,11)=MOUT(LINK)
      XL(LINK,12)=QUEOUT(LINK)
45    CONTINUE
52    CONTINUE
C     IF(NODT .EQ. 1)TYPE 1203,NT,N,VEH(N)
      IF(NODT .EQ. 1)XN(N,2)=VEH(N)
      IF(NODT .EQ. 2)XN(N,3)=EXIT(N)
      TOTEX=TOTEX+EXIT(N)
30    CONTINUE
C***** END OF NODE LOOP
      FRC=TOTEX/TOTPOP*PPV
c     TYPE 1605,NT,FRC
1605  FORMAT('  FOR INTERVAL',I4,' FRACTION OF EVACUATED POP =',F6.4)
C     WRITE(20'NT)XL,XN,TOTEX,FRC
      IF(NTM .EQ. 1)CALL DISP(NTM,VL)
      IF(FRC .LT. POPFRC)GOTO 10
      LTIME=NT
      TYPE 1405,LTIME
1405  FORMAT(5X,'LAST TIME INTERVAL IS NUMBER ',I5)
      ndone=1
      GOTO 75
10    CONTINUE
C***** END OF TIME LOOP
      LTIME=NTIMES
11    CONTINUE
      CALL JECCXX
      WRITE(12,1602)LTIME
1602  FORMAT(I6)
      WRITE(12,1612)(NODID(N),N=1,NNODES)
1612  FORMAT(80A1)
      TYPE 1603,LTIME,FRC
1603  FORMAT(//'  LAST TIME INTERVAL =',I6,
     *          /'  FRACTION OF POPOUT =',F6.4)
171   CONTINUE
      END
```

Figure C-1. (Continued.)

```
      SUBROUTINE DATA
C SUBROUTINE TO READ APPROPRIATE DOSE DATA
C PRESENTLY THREE FILES EXIT
C
C
      INCLUDE 'DSKD:DOSE.COM'
      DIMENSION A(41)
    DO 20 J=1,40
    READ(15,9001) (DOSE(I,J,1),I=1,40)
    READ(16,9001) (DOSE(I,J,2),I=1,40)
 20 READ(17,9001) (DOSE(I,J,3),I=1,40)
    READ(15,9001) A
    READ(16,9001) A
    READ(17,9001) A
9001  FORMAT(12E10.2)
      RETURN
      END
```

Figure C-2. Subroutine DATA.

```
      SUBROUTINE DISP(NTM,VL)
C SUBROUTINE TO DISPLAY LINK AND NODE CURRENT NUMERICAL DATA
C
C
      INCLUDE 'SYS$LIBRARY:COLORDEF'
      INCLUDE 'DSKD:PARAM.COM'
      INCLUDE 'DSKD:NODE.COM'
      INCLUDE 'DSKD:LINK.COM'
      INCLUDE 'DSKD:ROAD.COM'
      DIMENSION XLMONE(N2,12),XNMONE(N1,3),X(2),Y(2)
      DATA DENMAX,WIDMAX/500.,1.2/
      IROAD=YELLOW
      IQUE=ORANGE
      NCOUNT=0
      IF(NTM .NE. 1)GOTO 30
1     CONTINUE
      DO 10 L=1,NLINKS
      DO 10 J=1,12
10    XLMONE(L,J)=XL(L,J)
      DO 20 N=1,NNODES
      DO 20 J=1,3
20    XNMONE(N,J)=XN(N,J)
      IF(NCOUNT .EQ. 1)GOTO 100
30    CONTINUE
      DENCOR=WIDMAX/DENMAX
3000  FORMAT(1H1,'  LINK DENSITIES ARE AS FOLLOWS:',
     *        //12X,'DENSITY(VEH/MI)',
     *         /2X,'LINK',4X,'PRESENT',6X,'PAST')
      DO 40 L=1,NLINKS
      DENSIT=XL(L,12)*LNUML(L)
c     IF(L .EQ. 50 .OR. L .EQ. 100)PAUSE 21
      WIDTH=DENSIT*DENCOR*2.0
      IF(WIDTH .GT. WIDMAX)WIDTH=WIDMAX
      CALL JSLNSZ(WIDTH)
      NIN=LNIN(L)
      NOUT=LNOUT(L)
      X(1)=XNODE(NIN)
      X(2)=XNODE(NOUT)
      Y(1)=YNODE(NIN)
      Y(2)=YNODE(NOUT)
c     density color$$
      CALL JSCRXX(IROAD)
      IRTN=JPPL2A(X,Y,2)
      XT=X(1)-X(2)
      YT=Y(1)-Y(2)
      RLEN=SQRT(XT*XT+YT*YT)
      QLEN=XL(L,12)*VL/LNUML(L)
      RATIO=QLEN/RLEN
```

Figure C-3. Subroutine DISP.

```
      XQ=X(2)+XT*RATIO
      YQ=Y(2)+YT*RATIO
      CALL JSCRXX(IQUE)
      X(1)=XQ
      Y(1)=YQ
      QWID=FLOAT(LNUML(L))*WIDMAX
      CALL JSLNSZ(QWID)
      IRTN=JPPL2A(X,Y,2)
40    CONTINUE
3001  FORMAT(I5,4X,F7.2,4X,F7.2)
c     PAUSE 22
3002  FORMAT(1H1,'  NODE INFORMATION FOLLOWS:',
     *       //13X,'QUE(VEHICLES)',4X,'EXITING(VEHICLES)',
     *        /2X,'NODE',4X,'PRESENT',6X,'PAST',
     *          4X,'PRESENT',6X,'PAST')
      CALL JSLNSZ(0)
      DO 50 N=1,NNODES
      IF(NODID(N) .EQ. 'B    ')GOTO 50
      IF(NODID(N) .EQ. 'A    ')GOTO 51
      IF(NODID(N) .EQ. 'Z    ')GOTO 52
51    IF(XN(N,2).LE.0.0) GOTO 50
      XLOG=ALOG10(XN(N,2))+1
      CALL JSCRXX(ORANGE)
      GOTO 53
52    IF(XN(N,3).LE.0.0) GOTO 50
      XLOG=ALOG10(XN(N,3))+1
      CALL JSCRXX(GOLD)
53    DO 55 NC=1,4
      CALL GSARLI(20)
      RAD=0.12*FLOAT(NC)*XLOG/4.
      CALL GPAR2D(XNODE(N),YNODE(N),RAD,0.0,6.283)
   55 CONTINUE
      RAD=0.12*XLOG
      CALL GPAR2D(XNODE(N),YNODE(N),RAD,0.0,6.283)
50    CONTINUE
      NCOUNT=1
      GOTO 1
100   CONTINUE
      call jslnsz(0.)
      RETURN
      END
```

Figure C-3. (Continued.)

```
      SUBROUTINE DSCALC(NTM,T,TUPD,NDOSER,PPV)
C SUBROUTINE TO CALCULATE DOSES
C THIS IS SET UP FOR LLL DATA
C MARCH 1982
C
C
      INCLUDE 'DSKD:PARAM.COM'
      INCLUDE 'DSKD:DOSE.COM'
      INCLUDE 'DSKD:NODE.COM'
      INCLUDE 'DSKD:LINK.COM'
      INCLUDE 'DSKD:ROAD.COM'
      include 'dskd:text.com'
      DIMENSION PDOSE(40,40,3),PPDOSE(40,40,3)
C SET UP PAST DOSE MATRIX TO ALL ZEROS FIRST TIME IN
      IF(NTM .NE. 1)GOTO 10
C SET FRAC TO CORRESPOND TO CORRECT TIME PERIOD
C PPV IS PEOPLE PER VEHICLE--ALL XL AND XN VARIABLES ARE IN VEHICLES
      FRAC=T/TUPD*PPV
      DO 20 I=1,40
      DO 20 J=1,40
      DO 20 K=1,3
      PDOSE(I,J,K)=0.
20    PPDOSE(I,J,K)=0.
      GOTO 60
```

Figure C-4. Subroutine DSCALC.

```
10        CONTINUE
          IF(NDOSER .NE. 1)GOTO 60
          DO 50 I=1,40
          DO 50 J=1,40
          PDOSE(I,J,1)=DOSE(I,J,1)
          DO 50 K=2,3
          PDOSE(I,J,K)=DOSE(I,J,K)-PPDOSE(I,J,K)
50        PPDOSE(I,J,K)=DOSE(I,J,K)
60        CONTINUE
          DO 70 N=1,NRINGS
          RINPOP(N)=0.0
70        CONTINUE
C CALCULATE DOSE COMPONENT FROM NODE IN AND OUT QUES
C NOTE DOSE(I,J,1)WAS GIVEN AS A RATE (MREM/HR), NOT MREM
C CORRECTION IS MADE FOR THIS
          DO 30 N=1,NNODES
          NR=NODZON(N)
          NX=NGX(N)
          NY=NGY(N)
          XNUM=XN(N,2)+XN(N,3)
          XNUM2=PPV*XNUM
          DOS1=PDOSE(NX,NY,1)*FRAC*T
          DOS2=PDOSE(NX,NY,2)*FRAC
          DOS3=PDOSE(NX,NY,3)*FRAC
          TDOS1=TDOS1+DOS1*XNUM
          TDOS2=TDOS2+DOS2*XNUM
          TDOS3=TDOS3+DOS3*XNUM
          RINPOP(NR)=RINPOP(NR)+XNUM
30        CONTINUE
C ADD IN  DOSE COMPONENTS FOR LINK TRAVEL AND LINK QUE
          DO 40 L=1,NLINKS
          NX=NGX(LNOUT(L))
          NY=NGY(LNOUT(L))
          NR1=NODZON(LNIN(L))
          NR=NODZON(LNOUT(L))
          POPH=0.5*XL(L,8)*PPV
          DOS1=PDOSE(NX,NY,1)*FRAC*T
          DOS2=PDOSE(NX,NY,2)*FRAC
          DOS3=PDOSE(NX,NY,3)*FRAC
          TDOS1=TDOS1+DOS1*XL(L,9)
          TDOS2=TDOS2+DOS2*XL(L,9)
          TDOS3=TDOS3+DOS3*XL(L,9)
          RINPOP(NR)=RINPOP(NR)+XL(L,9)*PPV+POPH
          RINPOP(NR1)=RINPOP(NR1)+POPH
C ADD IN TRAVEL COMPONENT
          NSXG=NSLD(L)
          DO 40 J=1,NSXG
          DFRAC=DIST(L,J)/XLEN(L)*FRAC
          NX=IPX(L,J)
          NY=IPY(L,J)
          DOS1=PDOSE(NX,NY,1)*DFRAC*T
          DOS2=PDOSE(NX,NY,2)*DFRAC
          DOS3=PDOSE(NX,NY,3)*DFRAC
          TDOS1=TDOS1+DOS1*XL(L,8)
          TDOS2=TDOS2+DOS2*XL(L,8)
          TDOS3=TDOS3+DOS3*XL(L,8)
40        CONTINUE
          RETURN
          END
```

Figure C-4. (Continued.)

```
      SUBROUTINE ERROR
      TYPE 10
10    FORMAT(/' INCORRECT RESPONSE - TRY AGAIN')
      RETURN
      END
```

Figure C-5. Subroutine ERROR.

```
          SUBROUTINE HISTO(RINPOP,time)
C THIS ROUTINE PLOTS HISTOGRAMS OF POPULATION IN ONE MILE
C RINGS AROUND THE SITE.
C
          INCLUDE 'SYS$LIBRARY:COLORDEF'
          INCLUDE 'DSKD:TEXT.COM'
          DIMENSION RINPOP(11),X(2),Y(2),ltitle(25)
          EQUIVALENCE (X(1),X0),(X(2),X1),(Y(1),Y0),(Y(2),Y1)
C
          call fsxf80(0.,1.,0.,1.,0.,1.,0.,1.)
          call jnsgda('grid')
c
C label GRID
C
          CALL GSCP2D(.40,0.02)
          CALL GPTX2D('DISTANCE (MILES)$')
          CALL JSTXUP(1.,0.,0.)
          CALL GSCP2D(0.065,.4)
          CALL GPTX2D('POPULATION$')
          call gscp2d(.86,.01)
          call jscrxx(gold)
          call gptx2d('evacd$')
          CALL JSTXUP(0.,1.,0.)
          call jscrxx(white)
          CALL GSCP2D(.15,.95)
          CALL GPTX2D('TIME SINCE RELEASE$')
          CALL GSCP2D(.15,.92)
          ENCODE(15,300,LTITLE) TIME
300       FORMAT(4X,'= ',F4.2,' HRS$')
          CALL GPTX2D(LTITLE)
          call gscp2d(.15,.89)
          encode(18,301,ltitle) (ifix(zzin))
301       format('POP. IN =',i6,' $')
          call gptx2d(ltitle)
          call gscp2d(.15,.86)
          encode(18,302,ltitle) (ifix(zzout))
302       format('POP. OUT =',i6,' $')
          call gptx2d(ltitle)
          call gscp2d(.15,.83)
          frc100=100.*frc
          encode(14,303,ltitle) frc100
303       format(f5.1,'% EVACD $')
          call gptx2d(ltitle)
          call gscp2d(.15,.8)
          encode(21,304,ltitle) (ifix(tpopn))
304       format('TOTAL POP. =',i7,' $')
          call gptx2d(ltitle)
          call gscp2d(.6,.95)
          call gptx2d('ACCUMULATED POP.$')
          call gscp2d(.6,.92)
          call gptx2d('  DOSES - MREM$')
          call gscp2d(.6,.89)
          encode(18,401,ltitle) tdos1
401       format('I-131:',1pe9.2,'  $')
          call gptx2d(ltitle)
          call gscp2d(.6,.86)
          encode(18,402,ltitle) tdos2
402       format('xe-133:',1pe9.2,' $')
          call gptx2d(ltitle)
          call gscp2d(.6,.83)
          encode(18,403,ltitle) tdos3
```

Figure C-6. Subroutine HISTO.

```
403     format('cs-137:',1pe9.2.' $')
        call gptx2d(ltitle)
c
c       grid
c
        XMIN=0.0
        XMAX=16.0
        YMIN=1.0
        YMAX=1.0E+06
c
        CALL JSCRXX(GREEN)
        CALL GRID1(2.XMIN.XMAX.YMIN.YMAX)
C
C PLOT HISTOGRAMS OUT TO 10 MILES
C
        CALL JSLNSZ(100./20.)
        Y0=0.0
        DO 10 I=1,10
        if(rinpop(I).le.0) goto 10
        Y1=ALOG10(RINPOP(I))
        X0=I
        X1=X0
        IRTN = JPPL2A(X.Y.2)
10      CONTINUE
C
C PLOT HISTOGRAM AT 15 MILES FOR THE REST OF THE POPULATION.
C
        CALL JSCRXX(GOLD)
        if(rinpop(11).le.0.0) goto 20
        Y1= ALOG10(RINPOP(11))
        X0=15.
        X1=X0
        CALL JPPL2A(X.Y.2)
c
20      CALL JSLNSZ(0)  !RESET LINE WIDTH
C
        RETURN
        END
```

Figure C-6. (Continued.)

```
        SUBROUTINE INITIA
C SUBROUTINE TO INITIALIZE PLOTTING METHODS
C THIS VERSION IS FOR DISPLA PACKAGE
C
C
        INCLUDE 'SYS$LIBRARY:COLORDEF'
        IGRID = GREEN
c       CALL BGNPL(0)
        XORIG=-15.
        YORIG=-15.
        XSTEP=3.75
        YSTEP=3.75
        xup = 15.
        yup = 15.
        xutm = 647.
        xsize = 30.
        yutm = 3678.
        ysize = 30.
        xmnutm = xutm
        xmxutm = xsize + xutm
        ymnutm = yutm
        ymxutm = ysize + yutm
        call gsxfdf(0)
        call fsxf80(0.,1.,0.,1.,0.,1.,0.,1.)
C
c       initialize grafcore
c
        call jnsgds('grid')
```

Figure C-7. Subroutine INITIA.

```
c       CALL TITLE('SAMPLE',6,'LAT',3,'LONG',4,8,8)
        CALL JSCRXX(ICRID)
        call grid1(0,xorig,xup,yorig,yup)
C       call grgr2d(0,xorig,xup,yorig,yup,xmnutm,xmxutm,ymnutm,ymxutm)
c       CALL GRAPH(XORIG,XSTEP,YORIG,YSTEP)
c       CALL FRAME
        RETURN
        END
```

Figure C-7. (Continued.)

```
        SUBROUTINE ISOPLT(tnext)
C SUBROUTINE TO PLOT APPROPRIATE ISOCURVES
C SUBROUTINE TAKES GRID VALUES AS INPUT AND DEVELOPS ISOCURVES
C
C
        INCLUDE 'DSKD:BOXES.COM'
        include 'dskd:aclevs.com'
C
c
        dimension vt(10)
        data nx,ny,ilevs / 40,40,4/
C
C READ GRID INITIALIZATION DATA
C
  50    CALL PLTSET(INUC,TNEXT)
        IF(INUC.EQ.0) GO TO 900
c
        call jivt2d(vt)
        call fsxf80(1.,40.,1.,40.,VT(1),vt(2),vt(3),vt(4))
c
        call gpctsl(aclevs,ilevs, u, nx, ny)
c
        call fsxf80(vt(5),vt(6),vt(7),vt(8),vt(1),vt(2),vt(3),vt(4))
c
 900    continue
        return
        end
```

Figure C-8. Subroutine ISOPLT.

```
        SUBROUTINE LNKSET
C SUBROUTINE TO DETERMINE LENGTH OF EACH LINK IN EACH GRID
C  FEBRUARY 1982
C
C
        INCLUDE 'DSKD:PARAM.COM'
        INCLUDE 'DSKD:NODE.COM'
        INCLUDE 'DSKD:LINK.COM'
        DIMENSION X1(M2),X2(M2),Y1(M2),Y2(M2),XP(M2),YP(M2),IP1(M2),
     *            IP2(M2)
C LOOP ON LINKS
        DO 10 L=1,NLINKS
C DETERMINE LINK BEGINNING AND END NODES. AND GRID LOCATIONS
        NIN=LNIN(L)
        NOUT=LNOUT(L)
        NGXB=NGX(NIN)
        NGXE=NGX(NOUT)
        NGYB=NGY(NIN)
        NGYE=NGY(NOUT)
        XB=XNODE(NIN)
        XE=XNODE(NOUT)
        YB=YNODE(NIN)
        YE=YNODE(NOUT)
```

Figure C-9. Subroutine LNKSET.

```
C CALCULATE X AND Y LENGTHS OF LINK
        DX=XB-XE
        DY=YB-YE
        XLEN(L)=SQRT(DX*DX+DY*DY)
C CALCULATE DELTAS FOR GRID LOCATIONS
        MX=NGXB-NGXE
        MY=NGYB-NGYE
C CALCULATE SLOPE AND Y-INTERCEPT IF DX IS NOT = 0
        IF(DX .EQ. 0.)GOTO 19
        SLOPE=DY/DX
        B=YB-SLOPE*XB
19      CONTINUE
C SET UP DIRECTIONALITY OF SEARCH FOR POINTS
        IF(MX) 31,32,32
31      MDIRX=1
        MCORX=0
        GOTO 33
32      MDIRX=-1
        MCORX=1
33      CONTINUE
        IF(MY) 34,35,35
34      MDIRY=1
        MCORY=0
        GOTO 36
35      MDIRY=-1
        MCORY=1
36      CONTINUE
C SET UP POINTS INTERCEPTED BY X GRID LINES
        NP=1
        X1(NP)=XB
        Y1(NP)=YB
        IP1(NP)=0
        IF(MX .EQ. 0)GOTO 41
        NGXEM=NGXE-MDIRX
        DO 40 N=NGXB,NGXEM,MDIRX
        NP=NP+1
        X1(NP)=GRIDX(N-MCORX)
        Y1(NP)=SLOPE*X1(NP)+B
        IP1(NP)=N
        IF(X1(NP) .EQ. XB .AND. Y1(NP) .EQ. YB)NP=NP-1
40      CONTINUE
        IF(X1(NP) .EQ. XE .AND. Y1(NP) .EQ. YE)GOTO 42
41      CONTINUE
        NP=NP+1
        X1(NP)=XE
        Y1(NP)=YE
        IP1(NP)=NGXE
42      CONTINUE
C       TYPE *,(X1(K),K=1,NP)
C       TYPE *,(Y1(K),K=1,NP)
        IF(MY .EQ. 0)GOTO 51
        MP=0
C SET UP POINTS INTERCEPTED BY Y GRID LINES
        NGYEM=NGYE-MDIRY
        DO 50 M=NGYB,NGYEM,MDIRY
        MP=MP+1
        Y2(MP)=GRIDY(M-MCORY)
        IP2(MP)=M
        IF(DX .EQ. 0.)GOTO 52
        X2(MP)=(Y2(MP)-B)/SLOPE
        GOTO 50
52      X2(MP)=XE
50      CONTINUE
C       TYPE *,(X2(K),K=1,MP)
C       TYPE *,(Y2(K),K=1,MP)
51      CONTINUE
C SORT OUT ALL GRID INTERCEPTS(X AND Y)
        NS=0
        MSTART=1
        IXYLDC=0
        DO 60 N=1,NP
        IYKLDC=0
```

Figure C-9. (Continued.)

```
      X=X1(N)
      Y=Y1(N)
      IF(N .EQ. 1)GOTO 74
      IF(MY .EQ. 0)GOTO 71
      MYB=MSTART
      IF(MYB .EQ. MP+1)GOTO 71
      DO 70 M=MYB,MP,1
      IYKLDC=M
      XX=X2(M)
      YY=Y2(M)
      IF(XX .LT. XLAST .AND. XX .LT. X  .OR.
     *   XX .GT. XLAST .AND. XX .GT. X )GOTO 71
      MSTART=MSTART+1
      IF(XX .EQ. XB .AND. YY .EQ. YB)GOTO 70
      NS=NS+1
      XP(NS)=XX
      YP(NS)=YY
      IPY(L,NS-1)=IP2(M)
      IF(NS .NE. 2)GOTO 76
      IPX(L,NS-1)=NGXB
      GOTO 77
76    CONTINUE
      IF(IXKLDC .EQ. 0)GOTO 86
      IPX(L,NS-1)=IP1(N)
      GOTO 77
86    CONTINUE
      IPX(L,NS-1)=IPX(L,NS-2)
77    CONTINUE
      XLAST=XX
      YLAST=YY
70    CONTINUE
      IYKLDC=0
      IF(N .NE. NP)GOTO 71
      IF(X .EQ. XLAST .AND. Y .EQ. YLAST)GOTO 60
      NS=NS+1
      XP(NS)=X
      YP(NS)=Y
      IPX(L,NS-1)=NGXE
      IPY(L,NS-1)=NGYE
      GOTO 60
71    CONTINUE
      IF(X .EQ. XLAST .AND. Y .EQ. YLAST)GOTO 60
      IF(IYKLDC .NE. 0)IXKLDC=1
74    CONTINUE
      NS=NS+1
      XP(NS)=X
      YP(NS)=Y
C     IF(N .NE. 1)GOTO 72
C     IPX(L,NS)=NGXB
C     IPY(L,NS)=NGYB
C     GOTO 73
72    CONTINUE
      IF(NS .EQ. 1 .AND. N .NE. NP)GOTO 73
      IPX(L,NS-1)=IP1(N)
      IF(NS .NE. 2)GOTO 78
      IF(IYKLDC .NE. 0)GOTO 95
      IPY(L,NS-1)=NGYB
      GOTO 73
78    CONTINUE
      IF(IYKLDC .EQ. 0)GOTO 79
95    IPY(L,NS-1)=IP2(IYKLDC)
C     IXKLDC=1
      GOTO 85
79    CONTINUE
      IF(MSTART .NE. MP+1)GOTO 94
      IPY(L,NS-1)=NGYE
      GOTO 96
94    CONTINUE
      IPY(L,NS-1)=IPY(L,NS-2)
96    CONTINUE
      IXKLDC=0
85    CONTINUE
```

Figure C-9. (Continued.)

```
73      CONTINUE
        XLAST=X
        YLAST=Y
60      CONTINUE
        IF(NX .EQ. 0 .AND. NY .EQ. 0)IPX(L.1)=NGXB
C DETERMINE NUMBER OF SEGMENTS PER LINK(NSLD).LENGTH OF EACH
C SEGMENT(DIST), AND GRID CELL LOCATION(NGLOCX AND NGLOCY)
C       TYPE *,(XP(K),K=1,NS)
C       TYPE *,(YP(K),K=1,NS)
        NC=0
        DO 80 N=1,NS
        IF(N .EQ. 1)GOTO 81
        NC=NC+1
        XA=XP(N)
        YA=YP(N)
        XDIF=XA-XZ
        YDIF=YA-YZ
        DIST(L,NC)=SQRT(XDIF*XDIF+YDIF*YDIF)
        IF(DIST(L,NC) .NE. 0.)GOTO 82
        NC=NC-1
82      CONTINUE
81      CONTINUE
        XZ=XP(N)
        YZ=YP(N)
80      CONTINUE
        NSLD(L)=NC
        LTOT=NC
        WRITE(13,2000)L,NSLD(L)
        DO 90 N=1,LTOT
90      WRITE(13,2001)IPX(L,N),IPY(L,N),DIST(L,N)
2001    FORMAT(2I8,1PE10.3)
2000    FORMAT(I6,I6,/10I6,/5E10.4)
10      CONTINUE
        CLOSE(UNIT=13)
        RETURN
        END
```

Figure C-9. (Continued.)

```
        SUBROUTINE NODSET
C SUBROUTINE TO DETERMINE WHERE NODES ARE LOCATED RELATIVE TO GRID
C  FEBRUARY 1982
C
C
        INCLUDE 'DSKD:PARAM.COM'
        INCLUDE 'DSKD:NODE.COM'
        OPEN(UNIT=13,file='dsk:EVACDB.NLD',status='new')
C SET UP GRID SPACING
        DO 40 N=1,NGRIDX
40      GRIDX(N)=DELX*FLOAT(N)+XCORN
        DO 50 N=1,NGRIDY
50      GRIDY(N)=DELY*FLOAT(N)+YCORN
C LOOP ON NODES
        DO 10 N=1,NNODES
C CALCULATE X AND Y DISTANCE FROM ZERO REFERENCE FOR EVACUATION
        DX=XNODE(N)-XZERO
        DY=YNODE(N)-YZERO
        RAD=SQRT(DX*DX+DY*DY)
C DETERMINE WHICH SECTOR(1-16) NODE IS LOCATED IN
        Z=ATAN2(DX,DY)*57.296
        IF(Z .LT. 0.)Z=Z+360.
        Z=Z+11.25
        IF(Z .GE. 360.)Z=Z-360.
        NODSEC(N)=IFIX(Z/22.5)+1
C DETERMINE WHICH RING(1-5) NODE IS LOCATED IN
        DO 20 K=1,NRINGS
        IF(RAD .GT. RING(K))GOTO 20
        NODZON(N)=K
        GOTO 21
```

Figure C-10. Subroutine NODSET.

```
20      CONTINUE
        TYPE 1000,N
1000    FORMAT('   NODE NUMBER ',I3,' IS OUT OF RANGE')
        NERROR=1
21      CONTINUE
C DETERMINE WHICH NODES ARE TO BE EVACUATED
C CONSIDER ONLY A-TYPE NODES
        IF(NODID(N) .NE. 'A    ')GOTO 32
        DO 30 J=1,NZONES
        NS=NSEC(J)
        IF(RAD .GT. ZONE(J))GOTO 30
        DO 31 I=1,NS
        IF(NODSEC(N) .NE. MSECS(J,I))GOTO 31
        NODVAC(N)=1
        GOTO 32
31      CONTINUE
30      CONTINUE
32      CONTINUE
C SET UP SQUARE GRID INDICES
        DX=XNODE(N)-XCORN
        DY=YNODE(N)-YCORN
        NGX(N)=IFIX(DX/DELX)+1
        NGY(N)=IFIX(DY/DELY)+1
        WRITE(13,2000)N,NODID(N),NODSEC(N),NODZON(N),NODVAC(N),
     *          NGX(N),NGY(N)
2000    FORMAT(I6,A1,5I6)
10      CONTINUE
        RETURN
        END
```

Figure C-10. (Continued.)

```
SUBROUTINE PLTEND
CALL JESCDA('GRID')
CALL JXCLFR
CALL JESCXX('GRID')
RETURN
END
```

Figure C-11. Subroutine PLTEND.

```
      SUBROUTINE PLTSET(INUC,TNEXT)
C SUBROUTINE TO SELECT AND PLOT CURVES
C
C
        INCLUDE 'SYS$LIBRARY:COLORDEF'
        INCLUDE 'DSKD:BOXES.COM'
        INCLUDE 'DSKD:DOSE.COM'
        include 'dskd:aclevs.com'
        include 'dskd:text.com'
        dimension aclev(4,3)     !$$
        DIMENSION LTITLE(20)
C
        read (8,*)  aclev        !read contour levels $$
c
C
C FIND OUT WHAT TYPE OF ISOPLETH SHOULD BE PLOTTED
C
   10 TYPE 1001
 1001 FORMAT(//' ENTER NUCLIDE TO BE PLOTTED.'/
     2/' ENTER "1" FOR I-131, OR'
     3/' ENTER "2" FOR XE-133, OR'
     4/' ENTER "3" FOR CS-137, OR'
     5/' ENTER "0" FOR NO PLOT AT THIS TIME STEP.')
```

Figure C-12. Subroutine PLTSET.

```
      ACCEPT *,INUC
      IF(INUC.EQ.0) RETURN
      IF(INUC.EQ.1.OR.INUC.EQ.2.OR.INUC.EQ.3) GO TO 15
      CALL ERROR
      GO TO 10
C
C LOAD THE APPROPRIATE VALUES FOR THIS PLOT INTO ARRAY U.
C
   15 DO 20 J=1,40
      DO 20 I=1,40
   20 U(I,J)=DOSE(I,J,INUC)
        do 16 i=1,ilevs !$$
        aclevs(i) = aclev(i,inuc)       !$$
 16     continue         !$$
C
C SET UP THE TEXT
C
        CALL JSCRXX(GREEN)
        CALL GSCP2D(6.,14.)
        IF(INUC.EQ.1) CALL GPTX2D('I-131 INHALATION$')
        IF(INUC.EQ.2) CALL GPTX2D('XE-133 DIRECT$')
        IF(INUC.EQ.3) CALL GPTX2D('CS-137 INHALATION$')
        CALL GSCP2D(6.,13.)
        CALL GPTX2D('DOSE ISOPLETHS$')
        CALL GSCP2D(6.,12.)
        ENCODE(12,150,LTITLE) TNEXT
150     FORMAT('AT',F5.2,' HRS$')
        CALL GPTX2D(LTITLE)
        CALL JSCRXX(MAGENTA)
        CALL GSCP2D(10.,11.)
        ENCODE(9,200,LTITLE) ACLEVS(1)
        CALL GPTX2D(LTITLE)
        CALL JSCRXX(LT_MAGENTA)
        CALL GSCP2D(10.,10.)
        ENCODE(9,200,LTITLE) ACLEVS(2)
        CALL GPTX2D(LTITLE)
        CALL JSCRXX(MED_MAGENTA)
        CALL GSCP2D(10.,9.)
        ENCODE(9,200,LTITLE) ACLEVS(3)
        CALL GPTX2D(LTITLE)
        CALL JSCRXX(WHITE)
        CALL GSCP2D(10.,8.)
        ENCODE(9,200,LTITLE) ACLEVS(4)
        CALL GPTX2D(LTITLE)
200     FORMAT(1PE8.2,'$')
        RETURN
        END
```

Figure C-12. (Continued.)

```
        SUBROUTINE SITE(ISITRD,TIME)
C SUBROUTINE TO PLOT OUT SITE SPECIFICS
C
C
        INCLUDE 'SYS$LIBRARY:COLORDEF'
        INCLUDE 'DSKD:PARAM.COM'
        INCLUDE 'DSKD:NODE.COM'
        INCLUDE 'DSKD:LINK.COM'
        include 'dskd:text.com'
        DIMENSION XSITE(6,46),YSITE(6,46),NSITE(6),ltitle(25)
        DIMENSION XPLT(46),YPLT(46),xxx(2),yyy(2)
        equivalence (xxx(1),x1),(yyy(1),y1),(xxx(2),x2),(yyy(2),y2)
        DATA NSITE/13,41,19,3,3,15/
        IROAD = YELLOW
        ILAKE=CYAN
        ICONTY=WHITE
        ISITE=ORANGE
        IGRID=GREEN
```

Figure C-13. Subroutine SITE.

```
        CINR=10.0
        COUTR=15.0
        OPEN(UNIT=18,file='DSK:SITE.INP',status='old')
        IF(ISITRD.NE.0) GO TO 30
C READ SITE DATA
c       CALL COMPRS
c
        call gndimd(0)
c       call vsilid      !COLOR MONITOR
        CALL LV11ID      !HARDCOPY
        call gsctlb(0)   !no labels on contours
        DO 10 I=1,6
        DO 10 J=1,NSITE(I)
   10   READ(18,1000) K,XSITE(I,J),YSITE(I,J)
        CLOSE(UNIT=18)
C PLOT THE SITE DATA
        CALL JSCRXX(IGRID)
   30   CALL INITIA
        call gsarli(200)          !circle segment count
        call gpar2d(0.0,0.0,CINR,0.0,6.283)
        call gpar2d(0.0,0.0,COUTR,0.0,6.283)
        CALL JSCRXX(ISITE)
        call gsarli(20) !circle segment count
        call gpar2d(0.0,0.0,0.3,0.0,6.283)
        DO 40 I=1,6
        IF(I.EQ.2) CALL JSCRXX(ILAKE)
        IF(I.GT.2) CALL JSCRXX(ICONTY)
        DO 50 J=1,NSITE(I)
        XPLT(J)=XSITE(I,J)
   50   YPLT(J)=YSITE(I,J)
        call gpcv2d(xplt,yplt,nsite(i))
 40     continue
C PLOT OUT ROAD NETWORK
        DO 100 L=1,NLINKS
        NIN=LNIN(L)
        NOUT=LNOUT(L)
        X1=XNODE(NIN)
        Y1=YNODE(NIN)
        X2=XNODE(NOUT)
        Y2=YNODE(NOUT)
c       CALL RLVEC(X1,Y1,X2,Y2,0000)
        CALL JSCRXX(IROAD)
        CALL GSARLI(8)
        CALL GPAR2D(X1,Y1,0.12,0.0,6.283)
        irtn = jppl2a(xxx,yyy,2)
        CALL GPAR2D(X2,Y2,0.12,0.0,6.283)
100     CONTINUE
 1000 FORMAT(I4,2F10.4)
        if(isitrd.gt.0) GO TO 90
        call jscrxx(igrid)
        call gscp2d(-14.,14.)
        encode(24,200,ltitle) tnotic
200     format('WARNING TIME =',F5.2,' HRS$')
        call gptx2d(ltitle)
        call gscp2d(-14.,13.)
        encode(21,201,ltitle) tdelay
201     format('PREP TIME =',F5.2,' HRS$')
        call gptx2d(ltitle)
        call gscp2d(-14.,12.)
        encode(21,202,ltitle) (ifix(tpopn))
202     format('TOTAL POP. =',I7,' $')
        call gptx2d(ltitle)
        RETURN
90      CALL JSCRXX(GREEN)
        CALL GSCP2D(-14.,14.)
        CALL GPTX2D('TIME SINCE RELEASE$')
        CALL GSCP2D(-14.,13.)
        ENCODE(15,300,LTITLE) TIME
300     FORMAT(4X,'= ',F4.2,' HRS$')
        CALL GPTX2D(LTITLE)
        call gscp2d(-14.,12.)
        encode(17,301,ltitle) (ifix(zzin))
```

Figure C-13. (Continued.)

```
301     format('POP. IN =',I6,'$')
        call gptx2d(ltitle)
        call gscp2d(-14.,11.)
        encode(17,302,ltitle) (ifix(zzout))
302     format('POP. OUT =',I6,'$')
        call gptx2d(ltitle)
        call gscp2d(-14.,10.)
        frc100=100.*frc
        encode(14,303,ltitle) frc100
303     format(f5.1,'% EVACD $')
        call gptx2d(ltitle)
        RETURN
        END
```

Figure C-13. (Continued.)

```
C       ACLEVS.COM
        COMMON /ACLEVS ACLEVS(4),ILEVS
```

Figure C-14. Common file ACLEVS.COM.

```
C       BOXES.COM
      COMMON /BOXES/ XGRID(40),YGRID(40),XORIG,YORIG,XDELT
     1,YDELT,U(40,40)
```

Figure C-15. Common file BOXES.COM.

```
C       DOSE.COM
        COMMON/DOSE/DOSE(40,40,3)
```

Figure C-16. Common file DOSE.COM.

```
C       LINK.COM
C COMMON FOR LINK DATA
        COMMON/LNK1/NLINKS,LNIN(N2),LNOUT(N2),DIST(N2,M1),IPX(N2,M1),
     *                 IPY(N2,M1),NSLD(N2),LNUML(N2),xlen(n2)
```

Figure C-17. Common file LINK.COM.

```
C       NODE.COM
C COMMON FOR NODE DATA
        COMMON/NOD1/NNODES,XZERO,YZERO,XNODE(N1),YNODE(N1),NODSEC(N1),
     *                 RING(N5),NODZON(N1),NODID(N1),NSEC(N5),ZONE(N5),
     *                 MSECS(N5,N4),NODVAC(N1),NRINGS,NZONES,NERROR,
     *                 NGRIDX,NGRIDY,XCORN,YCORN,DELX,DELY,NGX(N1),NGY(N1),
     *                 GRIDX(N6),GRIDY(N6),rinpop(n5)
```

Figure C-18. Common file NODE.COM.

```
PARAMETER N1=200,N2=200,N3=20,N4=16,N5=15,N6=40,M1=25,M2=50
```

Figure C-19. Parameter.

```
C        ROAD.COM
         COMMON/ROAD/XL(N2,12),XN(N1,3)
```

Figure C-20. Common file ROAD.COM.

```
c        text.com
c common for text for displays
c also contains doses
         common /txt1/ zzin,zzout,frc,tnotic,tdelay,tpopn,tdos1,
     *                 tdos2,tdos3
```

Figure C-21. Common file TEXT.COM.

Appendix D: Input Files of Sample Case

```
300. 30. 3. .3 3. .3 .03 .003 .003 .0003 .00003 .000003
300. 30. 3. .3 10. 1. .1 .01 .01 .001 .0001 .00001
300. 30. 3. .3  10. 1. .1 .01 .01 .001 .0001 .00001
300. 30. 3. .3  10. 1. .1 .01 .01 .001 .0001 .00001
300. 30. 3. .3  10. 1. .1 .01 .03 .003 .0003 .00003
300. 30. 3. .3 30. 3. .3 .03 .03 .003 .0003 .00003
300. 30. 3. .3 30. 3. .3 .03 .03 .003 .0003 .00003
300. 30. 3. .3 30. 3. .3 .03 .03 .003 .0003 .00003
300. 30. 3. .3 30. 3. .3 .03 .03 .003 .0003 .00003
300. 30. 3. .3 30. 3. .3 .03 .03 .003 .0003 .00003
100. 10. 1. .1 30. 3. .3 .03 .03 .003 .0003 .00003
100. 10. 1. .1 30. 3. .3 .03 .03 .003 .0003 .00003
30. 3. .3 .03 30. 3. .3 .03 .03 .003 .0003 .00003
30. 3. .3 .03 30. 3. .3 .03 .03 .003 .0003 .00003
10. 1. .1 .01 30. 3. .3 .03 .03 .003 .0003 .00003
10. 1. .1 .01 30. 3. .3 .03 .03 .003 .0003 .00003
3. .3 .03 .003  30. 3. .3 .03 .03 .003 .0003 .00003
.3 .03 .003 .0003  30. 3. .3 .03 .03 .003 .0003 .00003
```

Figure D-1. Common input file ACLEVS.DAT—contour levels to be plotted each time step.

```
RANCHO SECO TEST CASE 3--BUCKLEY--01MARCH82
2 .004 .05 .25  .85 1
100 103 123 30
     1B -2.16 -0.57
     2B -2.13 -1.68
     3A -2.82 -1.71
     4A -2.83 -2.75
     5B -2.84 -3.86
     6A -2.85 -5.99
     7B -2.73 -6.88
     8A -2.70 -8.12
     9B -2.70 -9.24
    10Z -2.66-10.28
    11B -2.67 -0.34
    12A -2.66  1.15
    13A -2.69  3.57
    14B -3.23  5.17
    15B -4.46  6.06
    16B -5.95 -3.89
    17A -5.96 -4.99
    18B -5.99 -6.04
    19B -5.97 -6.56
    20B -5.99 -8.15
    21Z -5.97 -9.32
    22B -5.95 -2.87
    23B -5.96 -1.78
    24B -5.86 -0.11
    25A -5.86  2.60
    26B -5.92  4.70
    27B -7.05  4.79
    28A -0.49 -9.23
    29B  0.89 -9.23
    30B  1.98 -9.74
    31B -3.81 -9.26
    32B -4.88 -9.27
    33A -0.51 -8.13
    34B  1.91 -8.10
    35B -3.79 -8.14
    36B -4.88 -8.13
```

Figure D-2. Common input file EVACDB.INP—road network information.

```
37Z -9.04 -8.16
38Z -9.87 -6.72
39B -7.66 -6.08
40B -9.24 -6.10
41Z-10.16 -6.11
42A -7.64 -4.99
43A -3.93 -0.07
44A -7.63 -0.15
45B -7.59 -0.65
46B-10.15 -0.61
47B-10.14 -1.47
48A  1.10 -3.76
49A -0.02 -3.78
50A -1.56 -3.82
51A -7.42 -3.91
52B -9.25 -3.96
53Z-11.00 -3.97
54A  2.95 -2.88
55A  0.56 -0.51
56B -6.93 -1.42
57Z-11.84 -1.46
58A -5.14  6.05
59B -3.93  7.36
60A -3.47  8.52
61B -2.93  9.73
62B -5.73  5.72
63B -6.30  5.35
 64  6.3900E+02  1.0000E+03  1.0000E+00
 67  1.0000E+04  1.0000E+03  1.0000E+00
 58  6.3900E+02  1.0000E+03  1.0000E+00
 60  2.2000E+02  1.0000E+03  1.0000E+00
  1  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0   1   2       0.      0.
  2  0.70 1 45.0  2000.   1.0   1.0   1.0 -1.0   2   3       0.      0.
  3  1.00 1 45.0  2000.   1.0   1.0   1.0 -1.0   3   4       0.      0.
  4  1.10 1 45.0    50.   1.0   1.0   1.0 -1.0   4   5       0.      0.
  5  2.10 1 45.0  2000.   1.0   1.0   1.0 -1.0   5   6       0.      0.
  6  0.90 1 45.0  2000.   1.0   1.0   1.0 -1.0   6   7       0.      0.
  7  1.20 1 45.0    50.   1.0   1.0   1.0 -1.0   7   8       0.      0.
  8  1.10 1 45.0  2009.   1.0   1.0   1.0 -1.0   8   9       0.      0.
  9  1.00 1 45.0  2000.   1.0   1.0   1.0 -1.0   9  10       0.      0.
 10  0.60 1 45.0  2000.   1.0   1.0   1.0 -1.0   1  11       0.      0.
 11  1.50 1 45.0  2000.   1.0   1.0   1.0 -1.0  11  12       0.      0.
 12  2.30 1 45.0  2000.   1.0   1.0   1.0 -1.0  12  13       0.      0.
 13  1.70 1 45.0  2000.   1.0   1.0   1.0 -1.0  13  14       0.      0.
 14  1.50 1 45.0  2000.   1.0   1.0   1.0 -1.0  14  15       0.      0.
 15  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  16  17       0.      0.
 16  1.00 1 45.0  2000.   1.0   1.0   1.0 -1.0  17  18       0.      0.
 17  0.50 1 45.0  2000.   1.0   1.0   1.0 -1.0  18  19       0.      0.
 18  1.60 1 45.0  2000.   1.0   1.0   1.0 -1.0  19  20       0.      0.
 19  1.20 1 45.0  2060.   1.0   1.0   1.0 -1.0  20  21       0.      0.
 20  1.00 1 45.0  2000.   1.0   1.0   1.0 -1.0  16  22       0.      0.
 21  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  22  23       0.      0.
 22  1.60 1 45.0  2000.   1.0   1.0   1.0 -1.0  24  23       0.      0.
 23  2.70 1 45.0  2000.   1.0   1.0   1.0 -1.0  24  25       0.      0.
 24  2.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  25  26       0.      0.
 25  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  26  27       0.      0.
 26  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  23  22       0.      0.
 27  1.40 1 45.0  2000.   1.0   1.0   1.0 -1.0  28  29       0.      0.
 28  1.20 1 45.0  2000.   1.0   1.0   1.0 -1.0  29  30       0.      0.
 29  2.20 1 45.0  2000.   1.0   1.0   1.0 -1.0  28   9       0.      0.
 30  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0   9  31       0.      0.
 31  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  31  32       0.      0.
 32  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  32  21       0.      0.
 33  2.30 1 45.0  2000.   1.0   1.0   1.0 -1.0  33  34       0.      0.
 34  2.20 1 45.0  2000.   1.0   1.0   1.0 -1.0  33   8       0.      0.
 35  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0   8  35       0.      0.
 36  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  35  36       0.      0.
 37  1.10 1 45.0  2000.   1.0   1.0   1.0 -1.0  36  20       0.      0.
 38  2.90 1 45.0  2000.   1.0   1.0   1.0 -1.0  20  37       0.      0.
 39  3.80 1 45.0  2000.   1.0   1.0   1.0 -1.0  19  38       0.      0.
 40  3.00 1 45.0  2000.   1.0   1.0   1.0 -1.0   6  18       0.      0.
 41  1.70 1 45.0  2000.   1.0   1.0   1.0 -1.0  18  39       0.      0.
```

Figure D-2. (Continued.)

42	1.60	1	45.0	2000.	1.0	1.0	1.0	-1.0	39	40	0.	0.
43	0.90	1	45.0	2000.	1.0	1.0	1.0	-1.0	40	41	0.	0.
44	1.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	39	18	0.	0.
45	1.60	1	45.0	2000.	1.0	1.0	1.0	-1.0	17	42	0.	0.
46	1.10	1	45.0	2000.	1.0	1.0	1.0	-1.0	42	39	0.	0.
47	1.90	1	45.0	2000.	1.0	1.0	1.0	-1.0	43	24	0.	0.
48	1.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	24	44	0.	0.
49	0.60	1	45.0	2000.	1.0	1.0	1.0	-1.0	44	45	0.	0.
50	2.50	1	45.0	2000.	1.0	1.0	1.0	-1.0	45	46	0.	0.
51	0.80	1	45.0	2000.	1.0	1.0	1.0	-1.0	46	47	0.	0.
52	1.10	1	45.0	2000.	1.0	1.0	1.0	-1.0	48	49	0.	0.
53	1.60	1	45.0	2000.	1.0	1.0	1.0	-1.0	49	50	0.	0.
54	1.20	1	45.0	2000.	1.0	1.0	1.0	-1.0	50	5	0.	0.
55	3.00	1	45.0	50.	1.0	1.0	1.0	-1.0	5	16	0.	0.
56	1.40	1	45.0	2000.	1.0	1.0	1.0	-1.0	16	51	0.	0.
57	1.80	1	45.0	2000.	1.0	1.0	1.0	-1.0	51	52	0.	0.
58	1.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	52	53	0.	0.
59	2.10	1	45.0	2000.	1.0	1.0	1.0	-1.0	32	40	0.	0.
60	3.30	1	35.0	2000.	1.0	1.0	1.0	-1.0	54	55	0.	0.
61	2.20	1	35.0	2000.	1.0	1.0	1.0	-1.0	55	1	0.	0.
62	1.30	1	45.0	2000.	1.0	1.0	1.0	-1.0	23	56	0.	0.

64A	-8.62	3.63
65B	-9.83	2.63
66Z	-12.43	-0.13
67A	-5.01	4.77
68B	-4.83	5.18
69B	-7.54	5.42
70B	-8.61	4.91
71Z	-10.39	6.36
72A	0.22	9.01
73B	-2.07	9.17
74Z	-4.27	11.19
75B	2.47	7.49
76B	3.82	6.33
77A	4.89	5.41
78B	7.84	4.06
79B	8.85	2.86
80B	-0.96	0.52
81B	0.44	0.53
82B	2.03	1.16
83A	3.96	3.15
84A	7.59	3.32
85B	11.38	1.69
86Z	12.03	0.77
87B	-3.10	-0.84
88B	4.30	8.50
89Z	4.45	10.22
90A	9.13	-0.89
91B	10.10	-0.13
92B	10.49	1.03
93A	9.14	-2.03
94B	9.75	-2.41
95B	11.73	-1.55
96B	6.93	-4.47
97B	4.57	-6.77
98B	2.99	-9.80
99A	1.92	-7.29
100Z	1.66	-10.31
101B	-0.47	-10.25
102B	0.92	-9.19
103B	0.94	-10.30

54	1.1000E+01	5.0000E+02	1.0000E+00
55	1.0000E+04	1.0000E+03	1.0000E+00
48	2.2000E+01	5.0000E+02	1.0000E+00
49	1.6000E+01	5.0000E+02	1.0000E+00
50	1.0000E+04	5.0000E+02	1.0000E+00
4	1.0000E+04	1.0000E+03	1.0000E+00
3	1.4200E+02	1.0000E+03	1.0000E+00
43	1.5200E+02	1.0000E+03	1.0000E+00
12	6.5000E+01	1.0000E+03	1.0000E+00
13	9.0000E+01	1.0000E+03	1.0000E+00
72	1.2000E+01	1.0000E+03	1.0000E+00

Figure D-2. (Continued.)

77	8.0000E+00	1.0000E+03	1.0000E+00
83	8.0000E+00	1.0000E+03	1.0000E+00
84	5.0000E+01	1.0000E+03	1.0000E+00
90	5.0000E+02	1.0000E+03	1.0000E+00
93	3.0000E+01	1.0000E+03	1.0000E+00
99	7.5000E+01	1.0000E+03	1.0000E+00
28	2.9000E+02	1.0000E+03	1.0000E+00
33	1.0000E+02	1.0000E+03	1.0000E+00
8	4.0900E+02	1.0000E+03	1.0000E+00
6	3.0000E+02	1.0000E+03	1.0000E+00
17	1.0000E+04	1.0000E+03	1.0000E+00
42	3.4500E+02	1.0000E+03	1.0000E+00
51	3.4500E+02	1.0000E+03	1.0000E+00
44	2.3600E+02	1.0000E+03	1.0000E+00
25	6.0000E+02	1.0000E+03	1.0000E+00

63	3.10	1	45.0	2000.	1.0	1.0	1.0	-1.0	56	47	0.	0.
64	1.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	47	57	0.	0.
65	1.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	58	59	0.	0.
66	1.20	1	45.0	2000.	1.0	1.0	1.0	-1.0	59	60	0.	0.
67	1.30	1	45.0	2000.	1.0	1.0	1.0	-1.0	60	61	0.	0.
68	0.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	58	62	0.	0.
69	0.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	62	63	0.	0.
70	0.90	1	45.0	2000.	1.0	1.0	1.0	-1.0	63	27	0.	0.
71	1.90	1	45.0	2000.	1.0	1.0	1.0	-1.0	27	64	0.	0.
72	1.60	1	45.0	2000.	1.0	1.0	1.0	-1.0	64	65	0.	0.
73	3.60	1	45.0	2000.	1.0	1.0	1.0	-1.0	65	66	0.	0.
74	0.40	1	45.0	2000.	1.0	1.0	1.0	-1.0	67	68	0.	0.
75	1.00	1	45.0	2000.	1.0	1.0	1.0	-1.0	68	15	0.	0.
76	1.40	1	45.0	2000.	1.0	1.0	1.0	-1.0	15	59	0.	0.
77	1.00	1	45.0	2000.	1.0	1.0	1.0	-1.0	68	62	0.	0.
78	1.30	1	45.0	2000.	1.0	1.0	1.0	-1.0	63	69	0.	0.
79	1.20	1	45.0	2000.	1.0	1.0	1.0	-1.0	69	70	0.	0.
80	2.20	1	45.0	2000.	1.0	1.0	1.0	-1.0	70	71	0.	0.
81	1.20	1	45.0	2000.	1.0	1.0	1.0	-1.0	64	70	0.	0.
82	3.90	1	45.0	2000.	1.0	1.0	1.0	-1.0	25	65	0.	0.
83	2.20	1	55.0	2000.	1.0	1.0	1.0	-1.0	72	73	0.	0.
84	1.00	1	55.0	2000.	1.0	1.0	1.0	-1.0	73	61	0.	0.
85	2.00	1	55.0	2000.	1.0	1.0	1.0	-1.0	61	74	0.	0.
86	2.60	1	55.0	2000.	1.0	1.0	1.0	-1.0	72	75	0.	0.
87	1.70	1	55.0	2000.	1.0	1.0	1.0	-1.0	75	76	0.	0.
88	1.40	1	55.0	2000.	1.0	1.0	1.0	-1.0	77	76	0.	0.
89	3.30	1	55.0	2000.	1.0	1.0	1.0	-1.0	77	78	0.	0.
90	1.50	1	55.0	2000.	1.0	1.0	1.0	-1.0	78	79	0.	0.
91	1.70	1	55.0	2000.	1.0	1.0	1.0	-1.0	1	80	0.	0.
92	1.40	1	55.0	2000.	1.0	1.0	1.0	-1.0	80	81	0.	0.
93	1.70	1	55.0	2000.	1.0	1.0	1.0	-1.0	81	82	0.	0.
94	2.70	1	55.0	2000.	1.0	1.0	1.0	-1.0	82	83	0.	0.
95	3.60	1	55.0	2000.	1.0	1.0	1.0	-1.0	83	84	0.	0.
96	1.30	1	55.0	2000.	1.0	1.0	1.0	-1.0	84	79	0.	0.
97	2.70	1	55.0	2000.	1.0	1.0	1.0	-1.0	79	85	0.	0.
98	1.10	1	55.0	2000.	1.0	1.0	1.0	-1.0	85	86	0.	0.
99	0.90	1	45.0	2000.	1.0	1.0	1.0	-1.0	1	87	0.	0.
100	3.50	1	45.0	2000.	1.0	1.0	1.0	-1.0	87	22	0.	0.
101	1.80	1	45.0	2000.	1.0	1.0	1.0	-1.0	22	51	0.	0.
102	2.20	1	55.0	2000.	1.0	1.0	1.0	-1.0	76	88	0.	0.
103	1.70	1	55.0	2000.	1.0	1.0	1.0	-1.0	88	89	0.	0.
104	1.20	1	55.0	2000.	1.0	1.0	1.0	-1.0	90	91	0.	0.
105	1.30	1	55.0	2000.	1.0	1.0	1.0	-1.0	91	92	0.	0.
106	1.60	1	55.0	2000.	1.0	1.0	1.0	-1.0	92	86	0.	0.
107	1.20	1	55.0	2000.	1.0	1.0	1.0	-1.0	90	93	0.	0.
108	0.70	1	55.0	2000.	1.0	1.0	1.0	-1.0	93	94	0.	0.
109	2.10	1	55.0	2000.	1.0	1.0	1.0	-1.0	94	95	0.	0.
110	2.30	1	55.0	2000.	1.0	1.0	1.0	-1.0	95	86	0.	0.
111	3.40	1	55.0	2000.	1.0	1.0	1.0	-1.0	94	96	0.	0.
112	3.20	1	55.0	2000.	1.0	1.0	1.0	-1.0	96	97	0.	0.
113	3.40	1	55.0	2000.	1.0	1.0	1.0	-1.0	97	98	0.	0.
114	1.00	1	55.0	2000.	1.0	1.0	1.0	-1.0	98	30	0.	0.
115	0.80	1	45.0	2000.	1.0	1.0	1.0	-1.0	99	34	0.	0.
116	1.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	34	30	0.	0.
117	0.70	1	45.0	2000.	1.0	1.0	1.0	-1.0	30	100	0.	0.
118	2.10	1	45.0	2000.	1.0	1.0	1.0	-1.0	101	10	0.	0.

Figure D-2. (Continued.)

```
119  1.00 1 45.0  2000.  1.0  1.0  1.0 -1.0  28 101     0.    0.
120  1.10 1 45.0  2000.  1.0  1.0  1.0 -1.0  35  31     0.    0.
121  1.10 1 45.0  2000.  1.0  1.0  1.0 -1.0  36  32     0.    0.
122  1.10 1 45.0  2000.  1.0  1.0  1.0 -1.0 102 103     0.    0.
123  0.70 1 45.0  2000.  1.0  1.0  1.0 -1.0 103 100     0.    0.
```

Figure D-2. (Continued.)

```
RANCHO SECO CASE 1--DW BUCKLEY--1MARCH82
 0. .0 .25
0 0 11 1
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 15.
10. 16
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
40 40 -15. -15. .75 .75
```

Figure D-3. Common input file EVACDB.CAS – specific evacuation case information.

```
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
```

Figure D-4. Common input file I131.LLNL – 40 × 40 doses due to ^{131}I each time step.

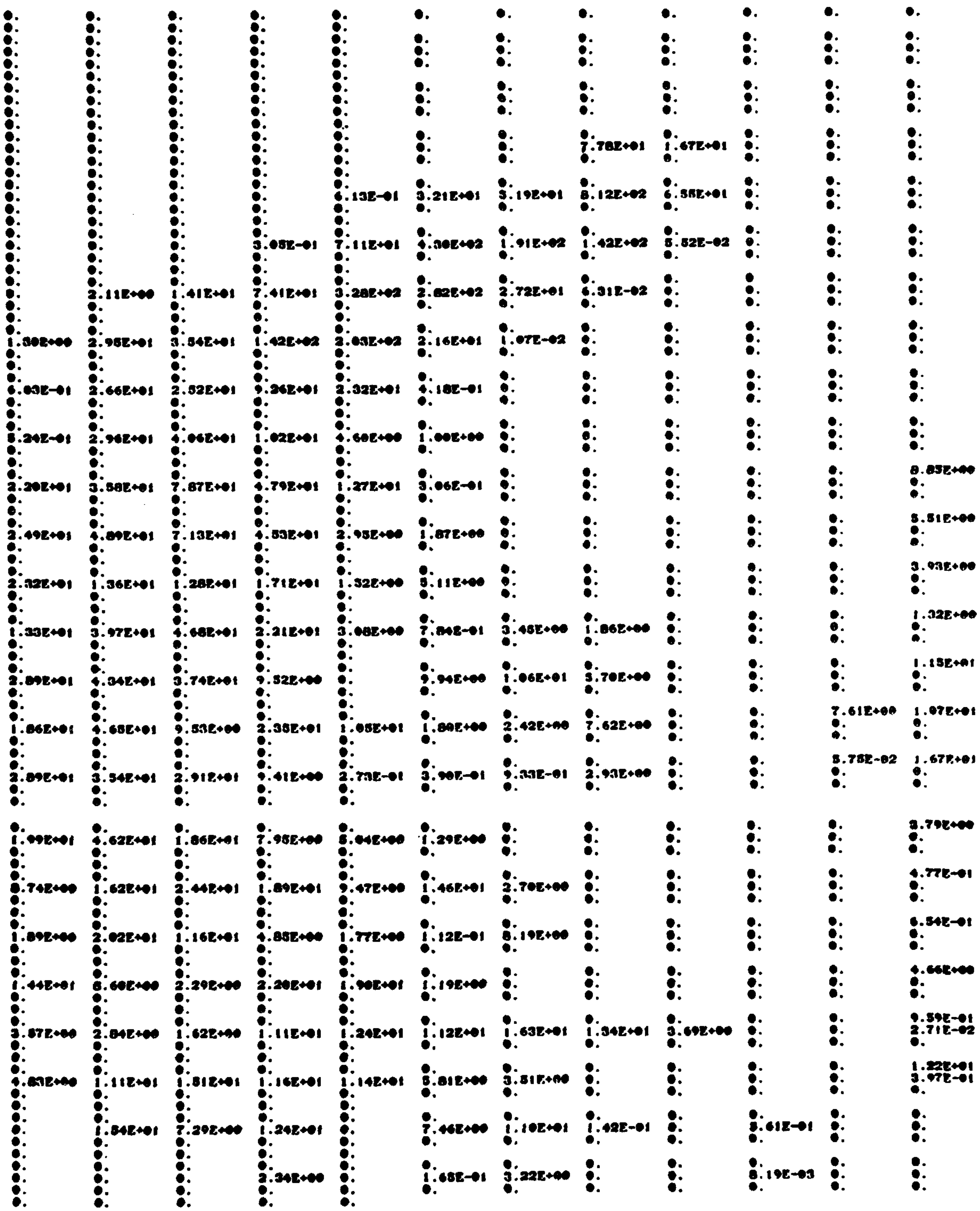

Figure D-4. (Continued.)

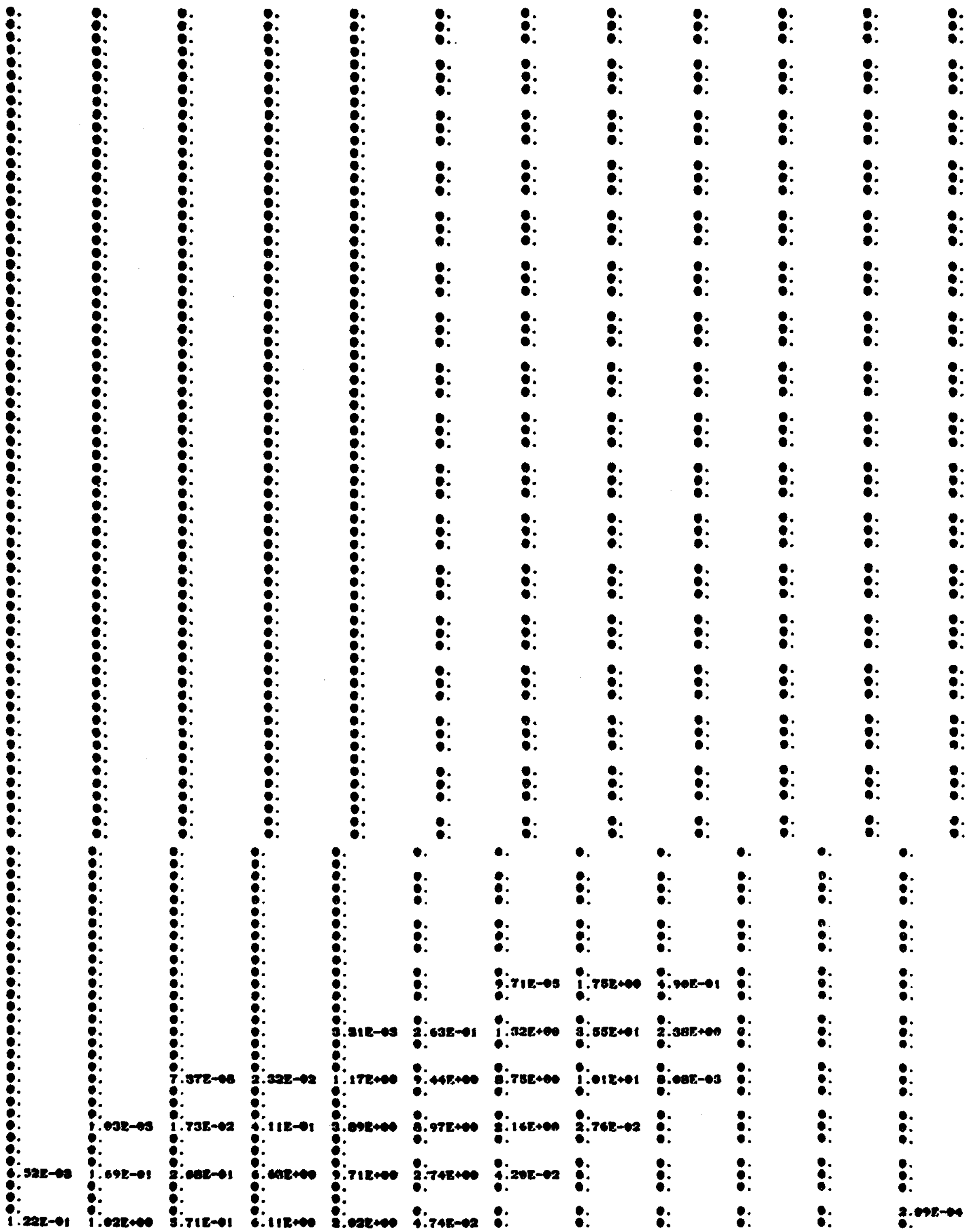

Figure D-5. Common input file XE133.LLNL – 40 × 40 doses due to ^{133}Xe each time step.

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.06E-02
4.01E-01	1.17E+00	1.32E+00	9.33E-01	8.19E-02	8.22E-02	2.58E-05	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.11E-06	5.49E-02
3.78E-01	1.50E+00	3.50E+00	2.30E+00	4.19E-01	1.68E-01	5.22E-04	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.25E-03	1.23E-01
4.14E-01	1.73E+00	2.87E+00	1.95E+00	4.05E-01	1.79E-01	3.28E-03	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.16E-02	1.17E-01
4.77E-01	1.31E+00	2.02E+00	1.25E+00	3.27E-01	2.24E-01	3.74E-02	1.60E-03	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.30E-03	1.99E-01
3.69E-01	9.61E-01	9.98E-01	8.29E-01	2.92E-01	3.10E-01	9.39E-02	1.78E-02	2.11E-07	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.61E-02	2.72E-01
1.65E-01	5.27E-01	5.44E-01	6.60E-01	2.26E-01	3.72E-01	1.61E-01	2.78E-02	3.57E-06	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	3.73E-03	8.97E-02	3.29E-01
3.01E-01	4.51E-01	3.57E-01	4.20E-01	3.80E-01	3.24E-01	1.57E-01	3.55E-02	1.06E-03	8.63E-04	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	2.76E-02	8.05E-02	1.60E-01
2.32E-01	3.57E-01	2.09E-01	2.31E-01	3.64E-01	2.17E-01	1.32E-01	7.10E-03	1.69E-05	6.37E-03	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	7.68E-03	4.76E-02	8.45E-02
2.18E-01	3.04E-01	2.02E-01	2.70E-01	2.10E-01	1.13E-01	7.74E-02	6.80E-03	2.65E-03	9.49E-03	0.	2.45E-04
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	9.71E-03	3.50E-02	3.74E-02
2.28E-01	2.73E-01	2.18E-01	2.12E-01	9.84E-02	6.40E-02	2.50E-02	3.70E-02	3.31E-02	1.15E-03	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	5.01E-03	3.01E-03	6.36E-03
4.83E-02	2.38E-01	2.20E-01	1.74E-01	6.90E-02	8.24E-02	9.04E-02	4.10E-02	1.85E-02	5.26E-03	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.69E-02
6.92E-02	2.90E-01	1.31E-01	7.27E-02	9.92E-02	6.68E-02	6.69E-02	2.36E-03	0.	9.61E-04	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.07E-02
7.16E-02	1.99E-01	8.71E-02	8.69E-02	8.15E-02	6.09E-02	2.87E-02	3.97E-03	0.	3.94E-02	1.79E-03	5.05E-04
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.76E-02
8.11E-02	4.47E-02	1.38E-02	1.06E-01	3.01E-02	5.28E-02	8.87E-03	2.48E-03	0.	3.46E-02	2.70E-04	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	9.47E-05	9.31E-05	3.62E-02	1.39E-02	3.52E-02	1.95E-03	2.36E-04	0.	4.94E-03	0.	4.43E-03
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	6.76E-06	2.79E-05	1.59E-03	2.45E-03	1.83E-03	0.	0.	0.	0.	0.	1.26E-03
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.						.	

Figure D-5. (Continued.)

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Figure D-6. Common input file CS137.LLNL – 40 × 40 doses due to ^{137}Cs each time step.

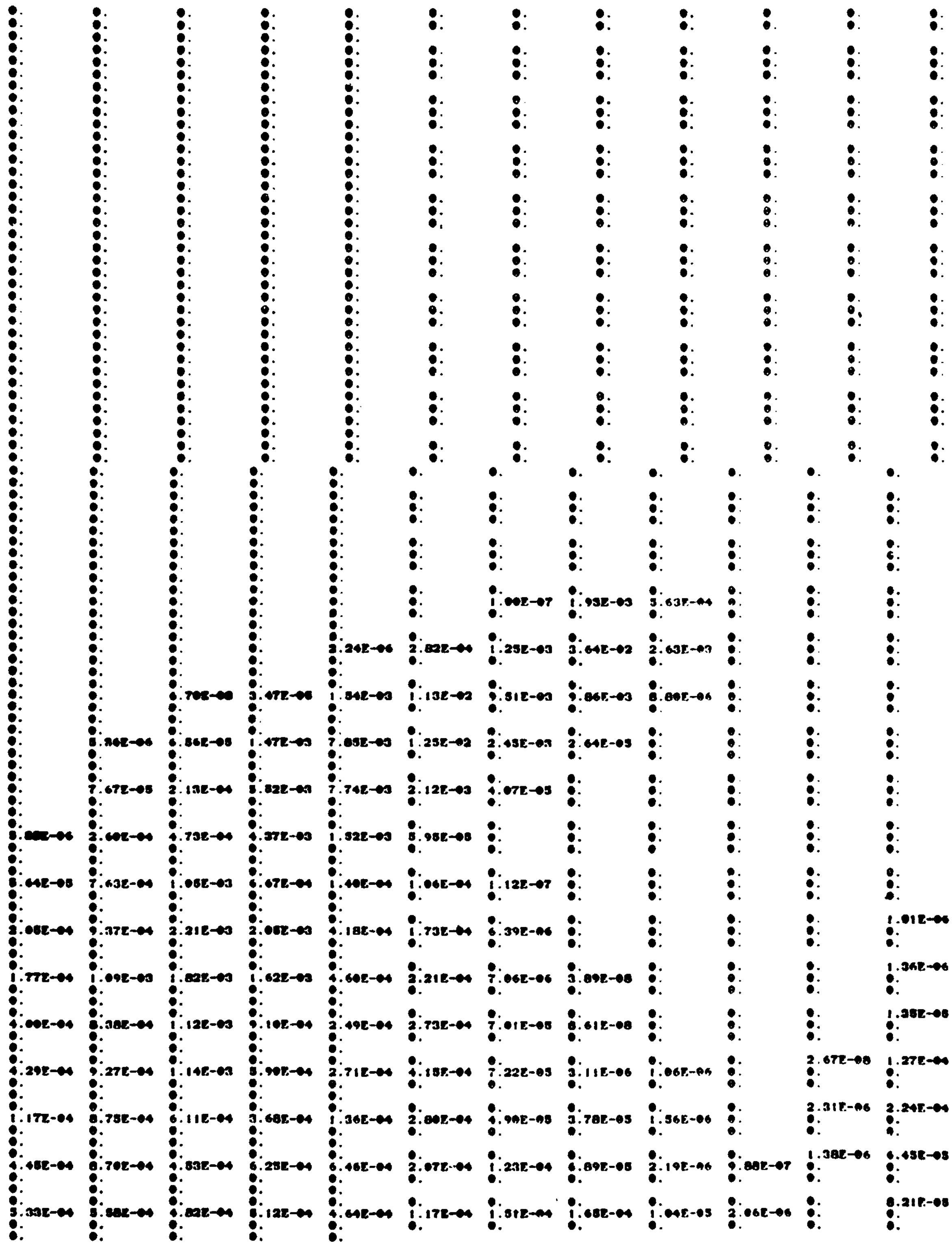

Figure D-6. (Continued.)

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.63E-04
4.96E-04	4.76E-04	4.99E-04	2.12E-04	2.46E-04	8.46E-05	2.81E-04	2.10E-04	7.16E-06	8.00E-06	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.63E-04
3.28E-04	3.00E-04	3.45E-04	1.13E-04	1.04E-04	1.37E-05	1.21E-04	5.78E-05	3.28E-05	1.68E-05	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.11E-05	5.89E-05
4.85E-05	2.29E-04	2.10E-04	1.72E-04	1.75E-04	4.40E-05	2.09E-05	9.17E-05	4.43E-05	3.74E-05	2.24E-06	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.39E-05	1.16E-04
5.02E-05	1.28E-04	3.56E-05	1.89E-04	1.07E-04	1.23E-05	5.27E-07	5.88E-06	1.67E-05	7.13E-05	2.18E-06	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]	2.95E-07
3.78E-05	3.24E-05	8.88E-07	9.67E-05	1.13E-05	3.05E-06	1.28E-06	5.19E-05	8.95E-06	1.37E-05	[illegible]	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	7.84E-07
1.21E-05	1.73E-05	8.64E-07	1.29E-05	5.72E-08	3.33E-07	1.61E-05	2.82E-06	3.08E-07	2.20E-05	4.51E-07	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.59E-05	4.66E-08	1.36E-09	0.	1.11E-06	7.76E-06	2.70E-05	2.58E-05	8.59E-06	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	1.00E-07	1.39E-07	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.							

Figure D-6. (Continued.)

Appendix E:
Discussion of Sample Case

Appendix E discusses the sample problem presented in this report. Figure E-1 illustrates the road network surrounding the Rancho Seco site. The numbers represent the 103 nodes. Table E-1 lists all the nodes where people enter the evacuation road network, the characteristics of each node including x- and

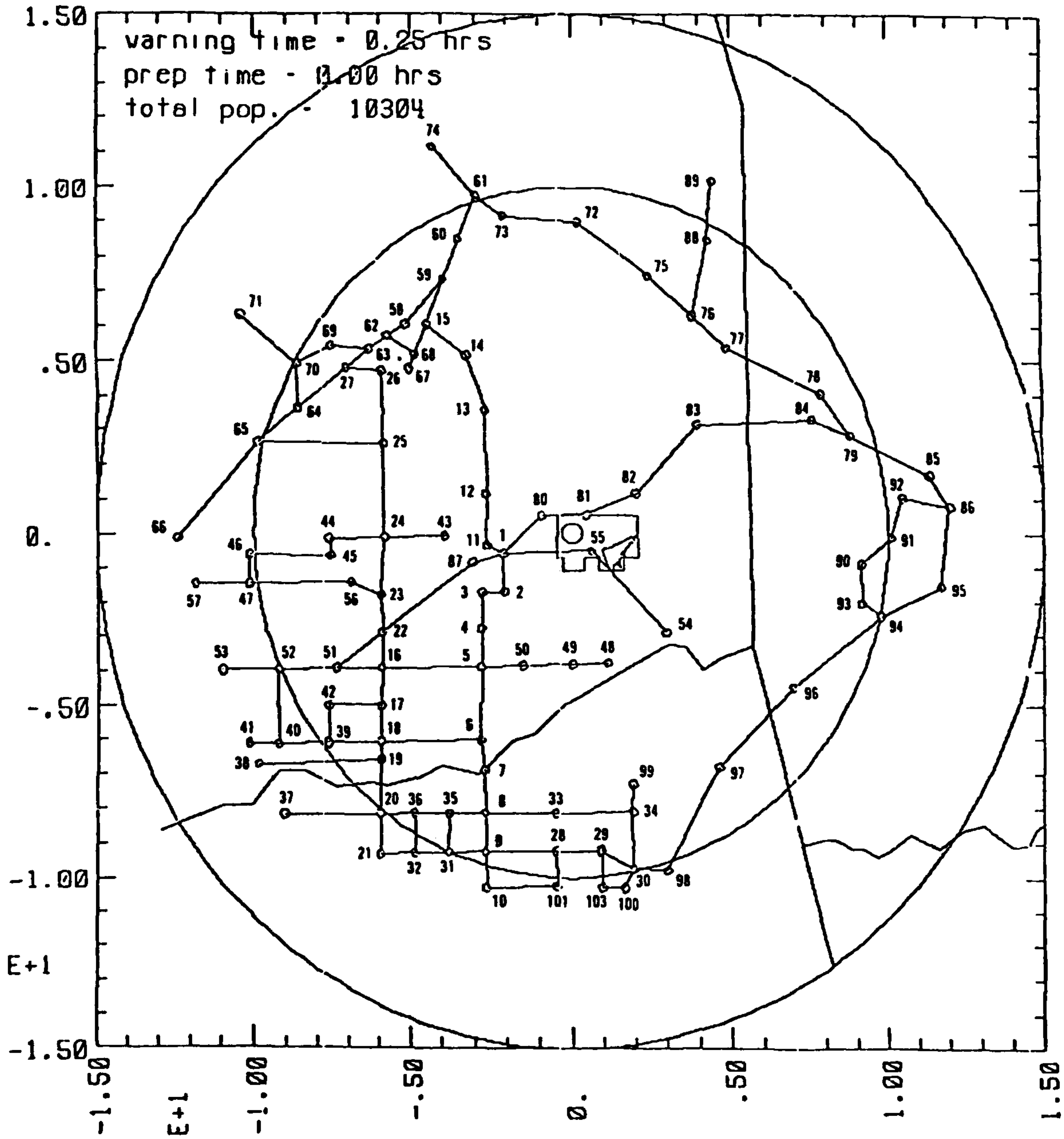

Figure E-1. Initial road network, with a node-numbering scheme, surrounding the Rancho Seco site.

y-location, the population entering the node, and the node capacity for entering vehicles. The total population involved is 10,304. Each node is identified as being an input, through, or output node. Input nodes are nodes that the evacuating population enters, and output nodes are nodes to which the evacuating population travels. The through nodes are those through which the evacuating population moves during travel from an input to an output node.

Table E-2 illustrates the characteristics of each link, including length, free-flow speed, capacity, number of lanes, and beginning and ending nodes. Potential road blocks are also indicated. Links 7, 55, and 85 have low road capacities. Since capacity is the number of vehicles that can pass through a link per hour, low capacities will cause roadblocks during heavy traffic periods. The low capacities of links 7, 55, and 85 during the evacuation result in queues that form on those links or on the feeder links leading to them.

The specific parameters for the sample problem are given in Table E-3. The problem was run using 0.01-h time steps and the results were reported every 0.25 h. The evacuation zone was up to 10 mi and included all sixteen 22.5° sectors (1 to 16).

Table E-1. Node characteristics of the sample problem for the Rancho Seco Nuclear Power Plant.

NODE ID	TYPE	LOCATION (MILES) X	Y	POPULATION ENTERING NODE(PEOPLE)	NODE CAPACITY (VEHICLES/HR)
1	B	-2.16	-0.57	0.	0.
2	B	-2.13	-1.68	0.	0.
3	A	-2.82	-1.71	142.	1000.
4	A	-2.83	-2.75	1000.	1000.
5	B	-2.84	-3.86	0.	0.
6	A	-2.85	-5.99	300.	1000.
7	B	-2.73	-6.88	0.	0.
8	A	-2.70	-8.12	409.	1000.
9	B	-2.70	-9.24	0.	0.
10	Z	-2.66	-10.28	0.	0.
11	B	-2.67	-0.34	0.	0.
12	A	-2.66	1.15	65.	1000.
13	A	-2.69	3.57	90.	1000.
14	B	-3.23	5.17	0.	0.
15	B	-4.46	6.06	0.	0.
16	B	-5.95	-3.89	0.	0.
17	A	-5.96	-4.99	1000.	1000.
18	B	-5.99	-6.04	0.	0.
19	B	-5.97	-6.56	0.	0.
20	B	-5.99	-8.15	0.	0.
21	Z	-5.97	-9.32	0.	0.
22	B	-5.95	-2.87	0.	0.
23	B	-5.96	-1.78	0.	0.
24	B	-5.86	-0.11	0.	0.
25	A	-5.86	2.60	600.	1000.
26	B	-5.92	4.70	0.	0.
27	B	-7.05	4.79	0.	0.
28	A	-0.49	-9.23	290.	1000.
29	B	0.89	-9.23	0.	0.
30	B	1.93	-9.74	0.	0.
31	B	-3.81	-9.26	0.	0.
32	B	-4.88	-9.27	0.	0.
33	A	-0.51	-8.13	100.	1000.
34	B	1.91	-8.10	0.	0.
35	B	-3.79	-8.14	0.	0.
36	B	-4.88	-8.13	0.	0.
37	Z	-9.04	-8.16	0.	0.
38	Z	-9.07	-6.72	0.	0.
39	B	-7.66	-6.08	0.	0.
40	B	-9.24	-6.10	0.	0.
41	Z	-10.16	-6.11	0.	0.
42	A	-7.64	-4.99	345.	1000.
43	A	-3.93	-0.07	152.	1000.
44	A	-7.63	-0.15	236.	1000.
45	B	-7.59	-0.65	0.	0.
46	B	-10.15	-0.61	0.	0.
47	B	-10.14	-1.47	0.	0.

Table E-1. (Continued.)

NODE ID	TYPE	LOCATION (MILES) X	Y	POPULATION ENTERING NODE(PEOPLE)	NODE CAPACITY (VEHICLES/HR)
48	A	1.10	-3.76	22.	500.
49	A	-0.02	-3.78	16.	500.
50	A	-1.56	-3.82	1000.	500.
51	A	-7.42	-3.91	345.	1000.
52	B	-9.25	-3.96	0.	0.
53	Z	-11.00	-3.97	0.	0.
54	A	2.95	-2.88	11.	500.
55	A	0.56	-0.51	1000.	1000.
56	B	-6.93	-1.42	0.	0.
57	Z	-11.84	-1.46	0.	0.
58	A	-5.14	6.05	639.	1000.
59	B	-3.93	7.36	0.	0.
60	A	-3.47	8.52	220.	1000.
61	B	-2.93	9.73	0.	0.
62	B	-5.73	5.72	0.	0.
63	B	-6.30	5.35	0.	0.
64	A	-8.62	3.63	639.	1000.
65	B	-9.83	2.63	0.	0.
66	Z	-12.43	-0.13	0.	0.
67	A	-5.01	4.77	1000.	1000.
68	B	-4.83	5.18	0.	0.
69	B	-7.54	5.42	0.	0.
70	B	-8.61	4.91	0.	0.
71	Z	-10.39	6.36	0.	0.
72	A	0.22	9.01	12.	1000.
73	B	-2.07	9.17	0.	0.
74	Z	-4.27	11.19	0.	0.
75	B	2.47	7.49	0.	0.
76	B	3.82	6.33	0.	0.
77	A	4.89	5.41	8.	1000.
78	B	7.84	4.06	0.	0.
79	B	8.85	2.86	0.	0.
80	B	-0.96	0.52	0.	0.
81	B	0.44	0.53	0.	0.
82	B	2.03	1.16	0.	0.
83	A	3.96	3.15	8.	1000.
84	A	7.59	3.32	50.	1000.
85	B	11.38	1.69	0.	0.
86	Z	12.03	0.77	0.	0.
87	B	-3.10	-0.84	0.	0.
88	B	4.30	8.50	0.	0.
89	Z	4.45	10.22	0.	0.
90	A	9.13	-0.89	500.	1000.
91	B	10.10	-0.13	0.	0.
92	B	10.49	1.03	0.	0.
93	A	9.14	-2.03	30.	1000.
94	B	9.75	-2.41	0.	0.
95	B	11.73	-1.55	0.	0.
96	B	6.93	-4.47	0.	0.
97	B	4.57	-6.77	0.	0.
98	B	2.99	-9.80	0.	0.
99	A	1.92	-7.29	75.	1000.
100	Z	1.66	-10.31	0.	0.
101	B	-0.47	-10.25	0.	0.
102	B	0.92	-9.19	0.	0.
103	B	0.94	-10.30	0.	0.

NODE TYPE: A = INPUT NODE
B = THRU NODE
Z = OUTPUT NODE

RELEASE POINT IS AT X=0 AND Y=0

Table E-2. Link characteristics of the sample problem for the Rancho Seco Nuclear Power Plant.

LINK ID	LENGTH (MILE)	FREE FLOW SPEED(MPH)	CAPACITY (VEHICLES/HR)	START NODE	END NODE	NUMBER OF LANES
1	1.10	45.	2000.	1	2	1
2	0.70	45.	2000.	2	3	1
3	1.00	45.	2000.	3	4	1
4	1.10	45.	1000.	4	5	1
5	2.10	45.	2000.	5	6	1
6	0.90	45.	2000.	6	7	1
7	1.20	45.	150.	7	8	1
8	1.10	45.	2000.	8	9	1
9	1.00	45.	2000.	9	10	1
10	0.60	45.	2000.	1	11	1
11	1.50	45.	2000.	11	12	1
12	2.30	45.	2000.	12	13	1
13	1.70	45.	2000.	13	14	1
14	1.50	45.	2000.	14	15	1
15	1.10	45.	2000.	16	17	1
16	1.00	45.	2000.	17	18	1
17	0.50	45.	2000.	18	19	1
18	1.60	45.	2000.	19	20	1
19	1.20	45.	2000.	20	21	1
20	1.00	45.	2000.	16	22	1
21	1.10	45.	2000.	22	23	1
22	1.60	45.	2000.	24	23	1
23	2.70	45.	2000.	24	25	1
24	2.10	45.	2000.	25	26	1
25	1.10	45.	2000.	26	27	1
26	1.10	45.	2000.	23	22	1
27	1.40	45.	2000.	28	29	1
28	1.20	45.	2000.	29	30	1
29	2.20	45.	2000.	28	9	1
30	1.10	45.	2000.	9	31	1
31	1.10	45.	2000.	31	32	1
32	1.10	45.	2000.	32	21	1
33	2.30	45.	2000.	33	34	1
34	2.20	45.	2000.	33	8	1
35	1.10	45.	2000.	8	35	1
36	1.10	45.	2000.	35	36	1
37	1.10	45.	2000.	36	20	1
38	2.90	45.	2000.	20	37	1
39	3.80	45.	2000.	19	38	1
40	3.00	45.	2000.	6	18	1
41	1.70	45.	2000.	18	39	1
42	1.60	45.	2000.	39	40	1
43	0.90	45.	2000.	40	41	1
44	1.70	45.	2000.	39	18	1
45	1.60	45.	2000.	17	42	1
46	1.10	45.	2000.	42	39	1
47	1.90	45.	2000.	43	24	1
48	1.70	45.	2000.	24	44	1
49	0.60	45.	2000.	44	45	1
50	2.50	45.	2000.	45	46	1
51	0.80	45.	2000.	46	47	1
52	1.10	45.	2000.	48	49	1
53	1.60	45.	2000.	49	50	1
54	1.20	45.	2000.	50	5	1
55	3.00	45.	150.	5	16	1
56	1.40	45.	2000.	16	51	1
57	1.80	45.	2000.	51	52	1
58	1.70	45.	2000.	52	53	1
59	2.10	45.	2000.	52	40	1
60	3.30	35.	2000.	54	55	1
61	2.20	35.	2000.	55	1	1
62	1.30	45.	2000.	23	56	1
63	3.10	45.	2000.	56	47	1
64	1.70	45.	2000.	47	57	1
65	1.70	45.	2000.	58	59	1
66	1.20	45.	2000.	59	60	1
67	1.30	45.	2000.	60	61	1
68	0.70	45.	2000.	58	62	1
69	0.70	45.	2000.	62	63	1
70	0.90	45.	2000.	63	27	1

Table E-2. (Continued.)

LINK ID	LENGTH (MILE)	FREE FLOW SPEED(MPH)	CAPACITY (VEHICLES/HR)	START NODE	END NODE	NUMBER OF LANES
71	1.90	45.	2000.	27	64	1
72	1.60	45.	2000.	64	65	1
73	3.60	45.	2000.	65	66	1
74	0.40	45.	2000.	67	68	1
75	1.00	45.	2000.	68	15	1
76	1.40	45.	2000.	15	59	1
77	1.00	45.	2000.	68	62	1
78	1.30	45.	2000.	63	69	1
79	1.20	45.	2000.	69	70	1
80	2.20	45.	2000.	70	71	1
81	1.20	45.	2000.	64	70	1
82	3.90	45.	2000.	25	65	1
83	2.20	55.	2000.	72	73	1
84	1.00	55.	2000.	73	61	1
85	2.00	55.	200.	61	74	1
86	2.60	55.	2000.	72	75	1
87	1.70	55.	2000.	75	76	1
88	1.40	55.	2000.	77	76	1
89	3.30	55.	2000.	77	78	1
90	1.50	55.	2000.	78	79	1
91	1.70	55.	2000.	1	80	1
92	1.40	55.	2000.	80	81	1
93	1.70	55.	2000.	81	82	1
94	2.70	55.	2000.	82	83	1
95	3.60	55.	2000.	83	84	1
96	1.30	55.	2000.	84	79	1
97	2.70	55.	2000.	79	85	1
98	1.10	55.	2000.	85	86	1
99	0.90	45.	2000.	1	87	1
100	3.50	45.	2000.	87	22	1
101	1.80	45.	2000.	22	51	1
102	2.20	55.	2000.	76	88	1
103	1.70	55.	2000.	88	89	1
104	1.20	55.	2000.	90	91	1
105	1.30	55.	2000.	91	92	1
106	1.60	55.	2000.	92	86	1
107	1.20	55.	2000.	90	93	1
108	0.70	55.	2000.	93	94	1
109	2.10	55.	2000.	94	95	1
110	2.30	55.	2000.	95	86	1
111	3.40	55.	2000.	94	96	1
112	3.20	55.	2000.	96	97	1
113	3.40	55.	2000.	97	98	1
114	1.00	55.	2000.	98	30	1
115	0.80	45.	2000.	99	34	1
116	1.70	45.	2000.	34	30	1
117	0.70	45.	2000.	30	100	1
118	2.10	45.	2000.	101	10	1
119	1.00	45.	2000.	28	101	1
120	1.10	45.	2000.	35	31	1
121	1.10	45.	2000.	36	32	1
122	1.10	45.	2000.	102	103	1
123	0.70	45.	2000.	103	100	1

Table E-3. Input parameters of the sample problem for the Rancho Seco Nuclear Power Plant.

```
INPUT PARAMETERS

   PEOPLE PER VEHICLE           =        2.0
   VEHICLE LENGTH(MI)           =   4.00E-03
   TIME INCREMENT(HR)           =      0.010
   NUMBER OF TIME INCREMENTS    =       1000
   REPORTING TIME(HR)           =      0.250
   NUMBER OF NODES              =        103
   NUMBER OF LINKS              =        123
   CUTOFF FRACTION              =     0.9000



SPECIFIC PARAMETERS FOLLOW:

     NOTIFICATION TIME(HR) =  0.25
     PREPARATION TIME(HR) =   0.00
     DISPERSION UPDATE(HR)=   0.25

     NUMBER OF EVACUATION ZONES = 1


     ZONE NUMBER 1 IS OUT TO 10.0 MILES
     INCLUDING SECTORS:
       1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16
```

U. S. Government Printing Office: 1983/9-687-002/8084